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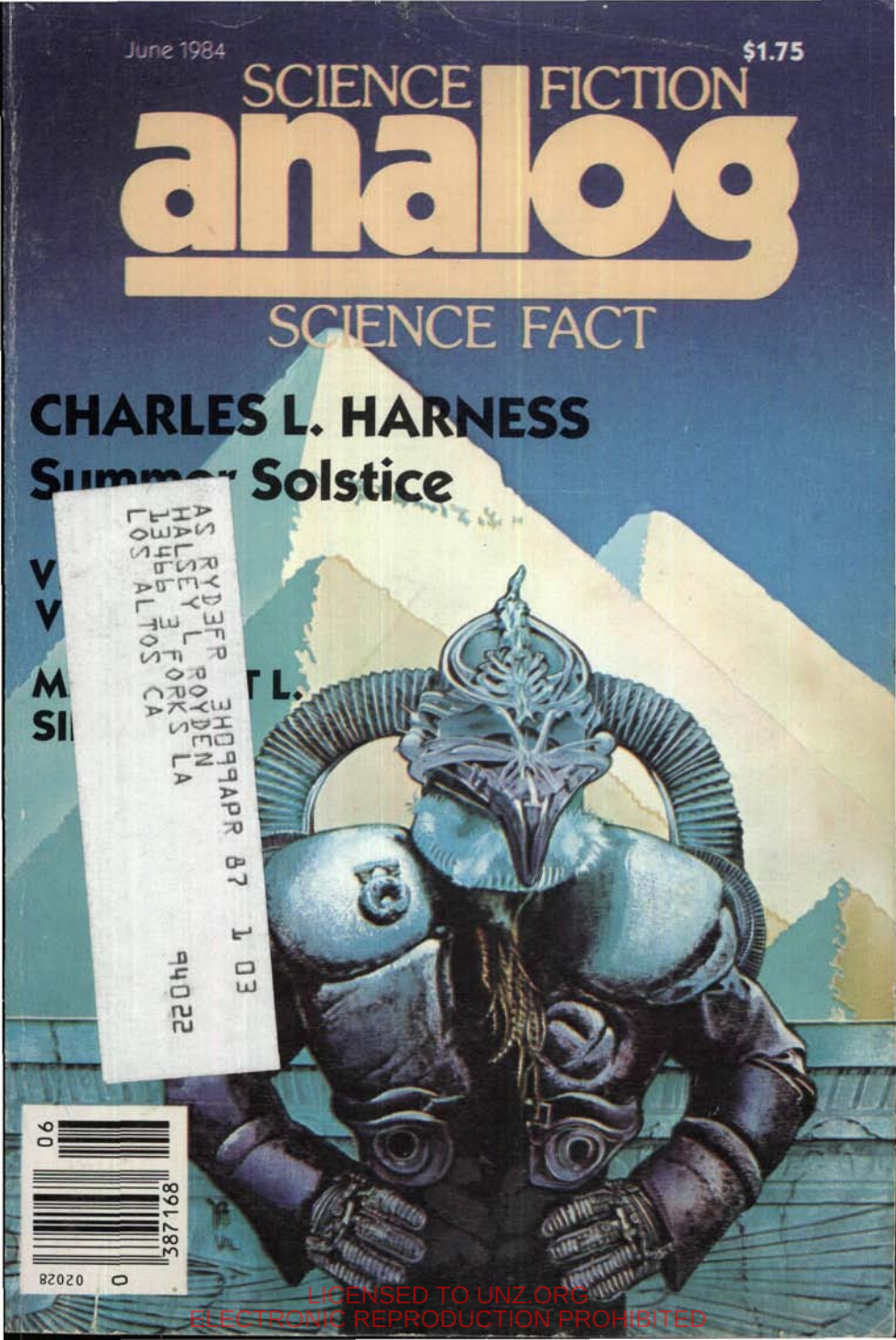

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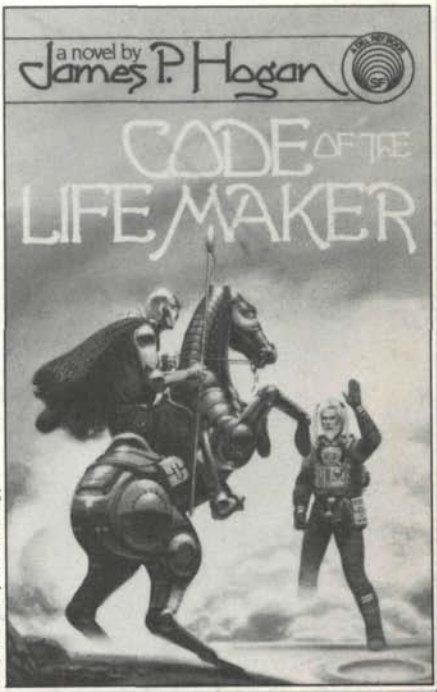

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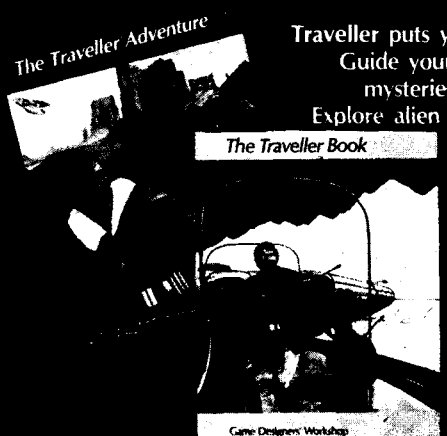

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Analog Science Fiction Science Fact is published 13 times annually by Davis Publications, Inc. at $1.75 a copy Jan.—Dec. issues, $1.95 Special Mid-Dec. issue. Annual subscription $19.50 in the U.S.A. and possessions, in all other countries $24.80 payable in advance in U.S. funds. First copy of new subscription will be mailed within eight weeks of receipt of order. When reporting change of address allow 6 to 8 weeks and give new address as well as the old address as it appears on the last label. Second-class postage paid at New York, NY, and at additional mailing office. Canadian 3rd class postage paid at Windsor, Ontario. © 1984 by Davis Publications, Inc., all rights reserved. Protection secured under the Universal Copyright Convention. Reproduction or use of editorial or pictorial content in any manner without express permission is prohibited. All stories in this magazine are fiction. No actual persons are designated by name or character. Any similarity is coincidental. Printed in U.S.A. All submissions must be accompanied by stamped self-addressed envelope, the publisher assumes no responsibility for unsolicited manuscripts or artwork.

POSTMASTER: SEND FORM 3579 to ANALOG SCIENCE FICTION/SCIENCE FACT, P.O. BOX 1936, MARION, OH 43306
IN CANADA RETURN TO 628 MONMOUTH ROAD, WINDSOR, ONTARIO N8Y 3L1
Editorial and Advertising Analog Science Fiction/Science Fact, 380 Lexington Avenue, New York, NY 10017
Subscriptions Analog Science Fiction/Science Fact, P.O. Box 1936, Marion, OH 43306 ISSN 0161-2328

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Editorial

INFALLIBILITY REQUIRED

Stanley Schmidt

The trouble with getting older and wiser is that it makes the victim more aware of his own ignorance. If your perspectives are sufficiently limited, it's easy to see Clear and Simple Solutions to nearly any problem. If you look at it from more angles, the simplicity often turns out to be illusory and solutions much less obvious.

Congress recently put into effect a new set of rules governing Medicare reimbursements to hospitals, which provide an interesting case in point. To some people, the new rules are the obvious and urgently needed response to a problem of runaway waste and inefficiency which was draining the system dry. To others, they are just as obviously another fine example of inappropriate application of statistical ideas to individual cases, quite likely to produce a disastrous decline in the quality of hospital treatment.

For myself, I can see the rationale of both sides—and enough complications in the whole issue to doubt seriously that the problem is going to be solved as simply as that. There *is* a problem, and the recent "solution" *will* cause new ones in the course of trying to deal with the old. The more I thought about the whole situation, the more tangled it seemed.

I'm still not sure I know "the answer," and I'm sure there are aspects of the problem to which I'm not going to do justice in these few pages. But I do think I see one crucial piece which doesn't seem to have been very generally recognized as part of this puzzle. And it leads me to believe that, as so often happens, the medicine is not being applied to the right part of the body politic—and a treatment that *does* get at the root of the problem will be much harder to administer, because it involves human attitudes.

To review the problem and solution as perceived and attacked by Congress:

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Nearly half of the revenues of American hospitals come from Medicare, and until last October these payments were in the form of payment for services rendered as billed by the hospital. Beginning in October, the procedure was changed to a "prospective payment" plan under which the Medicare administrators have a table of how much each type of illness "should" cost to treat—and that's how much the hospital gets.

It's rather like automobile mechanics getting a flat rate for fixing a starting problem, regardless of whether it's a loose wire which is obvious at a glance and takes a minute or two to fix, or a combination of subtle carburetor and ignition problems that take weeks to track down and cost hundreds of dollars in parts and labor to fix. On the face of it, it's a classic case of treating highly variable individual cases as if they all acted like some statistical average —highly unfair, in opposite ways, to any case whose actual costs are either far above or far below average.

The government's rationale for the change is based on what governments understand best: money. (Though just how well they really *understand* that may be open to question when you look at such evidence as the history of the national debt.) As Carolyne Davis, head of the Health Care Financing Administration, said of the old system, "The more hospitals spent, the more we paid." The criticism has a certain legitimacy: that type of arrangement can hardly be expected to encourage frugality. The Administration claims that because hospitals could get more by spending more, they were spending far more than they needed to on things like tests that were not really necessary. The new program is intended to make doctors and hospital administrators scrutinize such expenditures much more closely.

From the Financing Administration's point of view, it really doesn't matter whether they pay a lot for expensive cases and a little for cheap ones, or the same flat fee for all. All the money is coming from one pot, and only the total income and payout matter. Even from the hospitals' point of view, it doesn't *have* to matter—in the long run. Under the new rules a hospital has to cover the difference if it spends more on a case than Medicare provides, but it can *keep* the difference if it spends less. Over a long time, it will get both cheap and expensive cases, and if Medicare's flat rate equals or exceeds the actual average, the hospital can actually come out ahead by being "efficient." Of course, over *short* terms, a run of complicated cases could cause a hospital serious cash flow problems; and the smaller the hospital is, the less able it is to weather those.

And whether the new Medicare payments *will* cover actual costs is highly questionable. The whole idea behind the change was to reduce expenditures —which implies very clearly that the new payments will be appreciably lower than pre-October averages. The Financing Administration claims pre-October averages were too high because hospitals were operating inefficiently. Many people who actually deliver medical services in hospitals claim the new flat rates are too low and will go beyond

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"efficiency" (which most would agree is Desirable) to "cutting corners" (which usually carries a deservedly derogatory connotation).

Costs *can* be kept within the new limits, but only by cutbacks. The crucial question is whether those cutbacks can be limited to real waste, or whether they will go deeper—into the real meat of quality medical care. A doctor who formerly ordered "too many" tests now may order fewer than he really should because he has to be more concerned with a bookkeeper's bottom line than with his patient's health. He may become *unable* to order some tests because labs are forced to cut back on equipment and staff. Changes like that will affect *all* patients, not just those on Medicare. So will others like a general deterioration in the quality of training of all kinds of medical practitioners, especially in recent developments. Anybody working in a field as demanding and rapidly changing as medicine needs periodic exposure to things like courses and workshops to sharpen and update his or her skills. Until recently hospitals commonly provided financial aid to enable and encourage their employees to take advantage of these; now many have have sharply reduced or eliminated such aid. Many doctors can probably take care of themselves, but nurses and medical technologists who have to finance refreshers entirely on their own will increasingly skip them altogether. And patients will increasingly depend on personnel with outdated ideas and techniques.

It is probably true that some doctors *have* done things like ordering more

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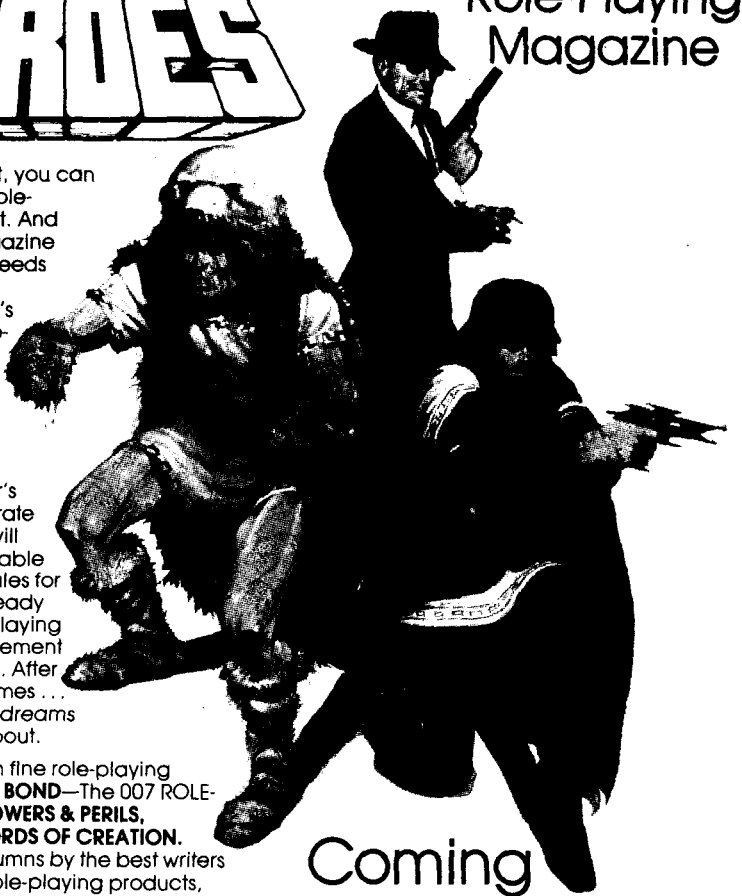

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tests than were truly necessary, and that has contributed to the need for something like the recent reform. But that fact does not alleviate the undesirable side effects, and already there are signs of realization even in Washington that the reform is going to need some reforming. What I haven't heard discussed much in this connection is *why* doctors order too many tests—and therein, I think, lies one of the major roots of this whole situation.

It may be that in some places and circumstances the doctor adds a "middleman" charge onto a test that he orders and so makes money on it. Certainly hospitals with labs made something on tests paid for by Medicare, and this could lead administrators to encourage doctors to make lots of use of the facilities. I can imagine, but not confirm, all kinds of intricate and sordid financial arrangements to take advantage of the old Medicare cornucopia, some of which probably happen occasionally. But I doubt that, in the country as a whole, all of them put together were as much of an inducement to excessive testing as the fear of malpractice suits.

In recent years, patients have been pressing—and winning—malpractice suits for larger and larger amounts for more and more far-fetched claims. As a result doctors now pay vast sums every year for malpractice insurance. It's hardly surprising if they want to cover themselves in advance by testing for every conceivable problem, however unlikely—not to protect patients against absurdly remote *medical* dangers, but to protect *themselves* against no less absurd but far more real *legal* ones. I've seen reports of malpractice cases that led me to marvel that doctors still have the nerve to *touch* patients.

The underlying problem here is not an epidemic of incompetence among doctors. It is an epidemic of grossly unrealistic expectations of what doctors can do—encouraged, unfortunately, by courts which should know better. People have come to believe that doctors should never make mistakes, and courts have reinforced this absurd requirement of infallibility by punishing breaches with settlements way out of proportion to actual damages.

But doctors are *not* infallible, it is unreasonable to expect them to be, and it will probably remain so for the foreseeable future. Medicine has learned to do a great deal, and some of it is even on a more or less scientific footing. But the human body is far more complicated than an automobile, and keeping it in good working order is still at least as much art as science. Some practitioners are inevitably better than others, but even the best spends much of his time dealing in educated guesses and probabilities—and almost none of it dealing with certainties.

The public—and the government—need a far better understanding of the difference between a diagnosis or treatment which is *wrong* and one which is known to fail one time in fifty even when carried out with the best available technique. If the former kills a patient, the doctor's incompetence should be dealt with with all the severity it deserves. But in the latter case—when the fiftieth patient dies after a quite reasonable prognosis of "98% chance of sur-

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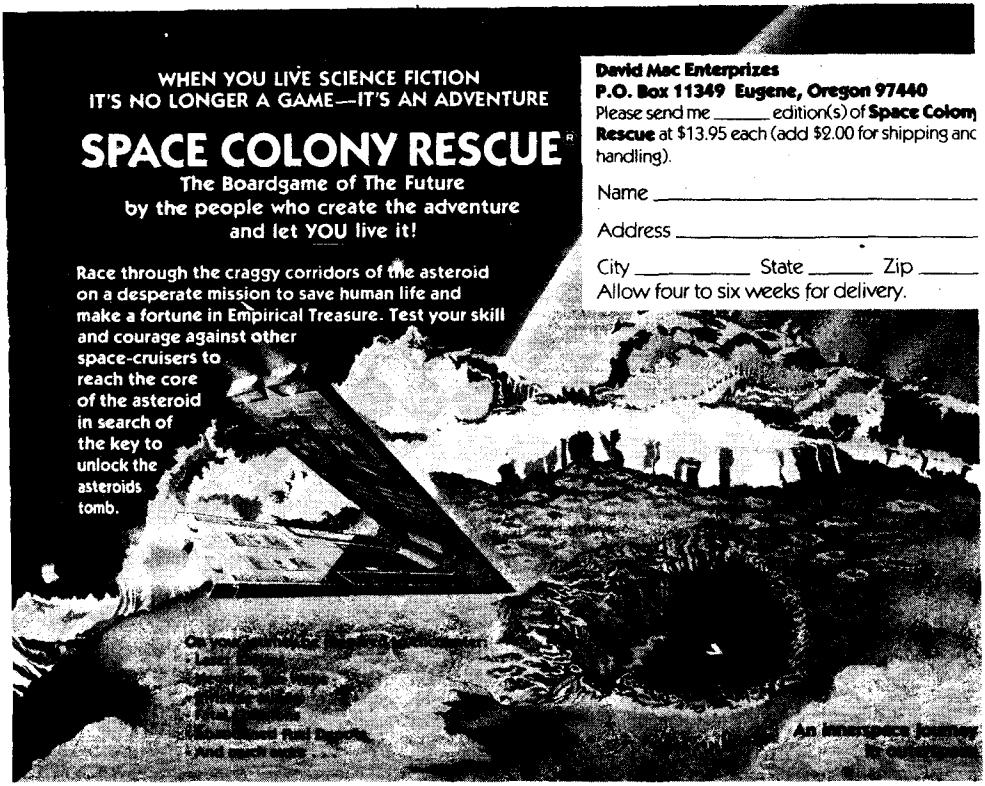
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vival''—there is no cause whatsoever for complaint or punishment.

I'm not suggesting the abolition of malpractice suits. Doctors *can* do genuinely stupid, careless or corrupt things which endanger life, and those should not be tolerated. But neither should they be confused with the inescapable fact that if a procedure is only capable of 90% success, one time in ten it *will fail*. And that's nobody's fault.

If we could educate patients—or at least judges—to more realistic expectations of medicine, that just might do far more for runaway costs than artificially homogenized payment plans and prescription by dollar sign. It would require much more general understanding of how medicine works.

But if enough of us understood that some mistakes are inevitable (and why), malpractice insurance could cost less, doctors could feel less compulsion to test for everything under the sun, and actual costs might come back into line with the Medicare budget—maybe even with enough left over to reinstate some ''extras'' like sending hospital staff to an occasional seminar to learn what's new.

And as a fringe benefit, getting some of the backlog of silly malpractice suits out of the courts might help unclog them enough to give more careful attention to important cases of *real* malpractice —medical or otherwise. ■

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Charles L. Harness

SUMMER SOLSTICE

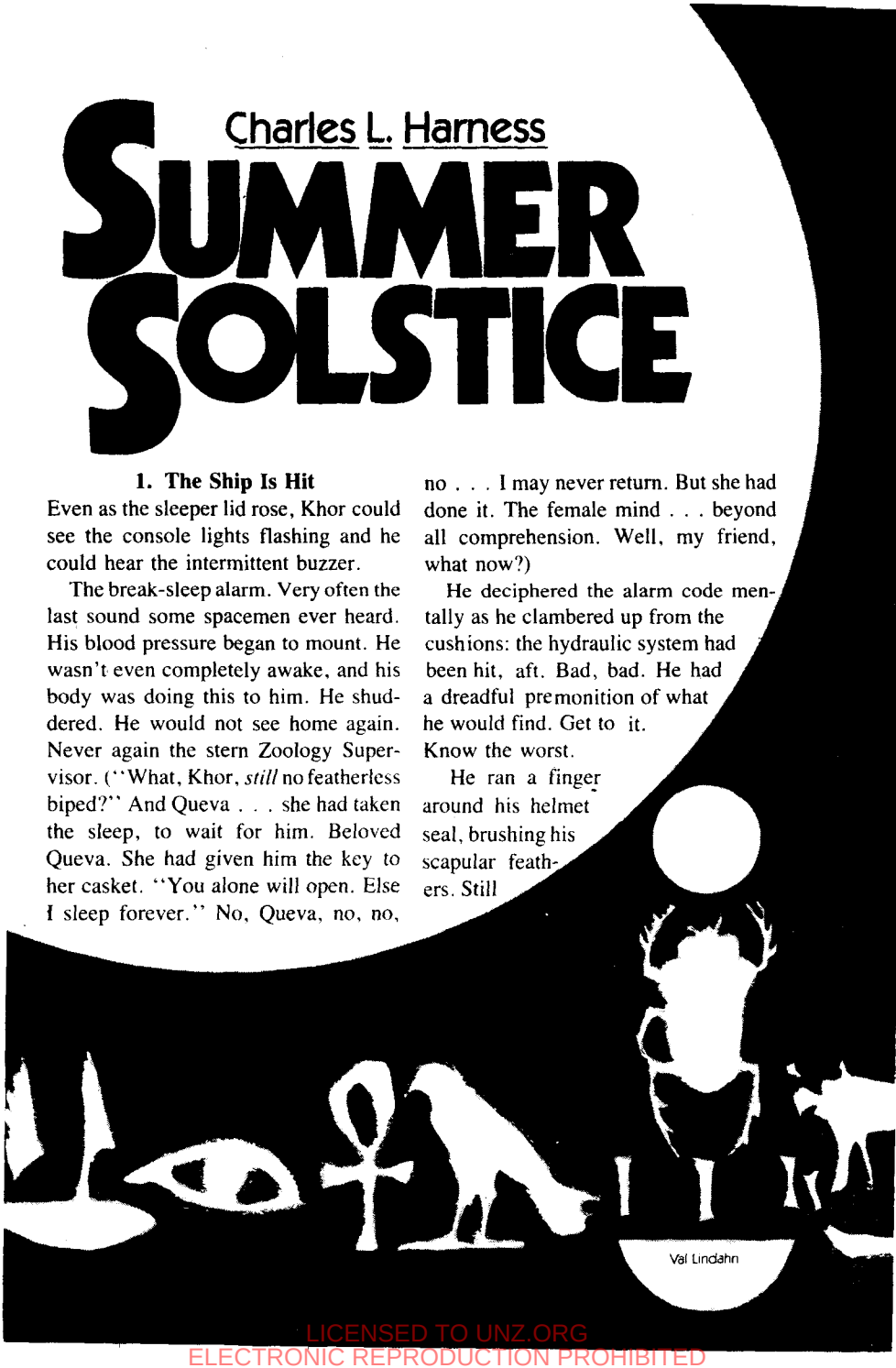
1. The Ship Is Hit

Even as the sleeper lid rose, Khor could see the console lights flashing and he could hear the intermittent buzzer.

The break-sleep alarm. Very often the last sound some spacemen ever heard. His blood pressure began to mount. He wasn't even completely awake, and his body was doing this to him. He shuddered. He would not see home again. Never again the stern Zoology Supervisor. ("What, Khor, *still* no featherless biped?" And Queva . . . she had taken the sleep, to wait for him. Beloved Queva. She had given him the key to her casket. "You alone will open. Else I sleep forever." No, Queva, no, no, no . . . I may never return. But she had done it. The female mind . . . beyond all comprehension. Well, my friend, what now?)

He deciphered the alarm code mentally as he clambered up from the cushions: the hydraulic system had been hit, aft. Bad, bad. He had a dreadful premonition of what he would find. Get to it. Know the worst.

He ran a finger around his helmet seal, brushing his scapular feathers. Still



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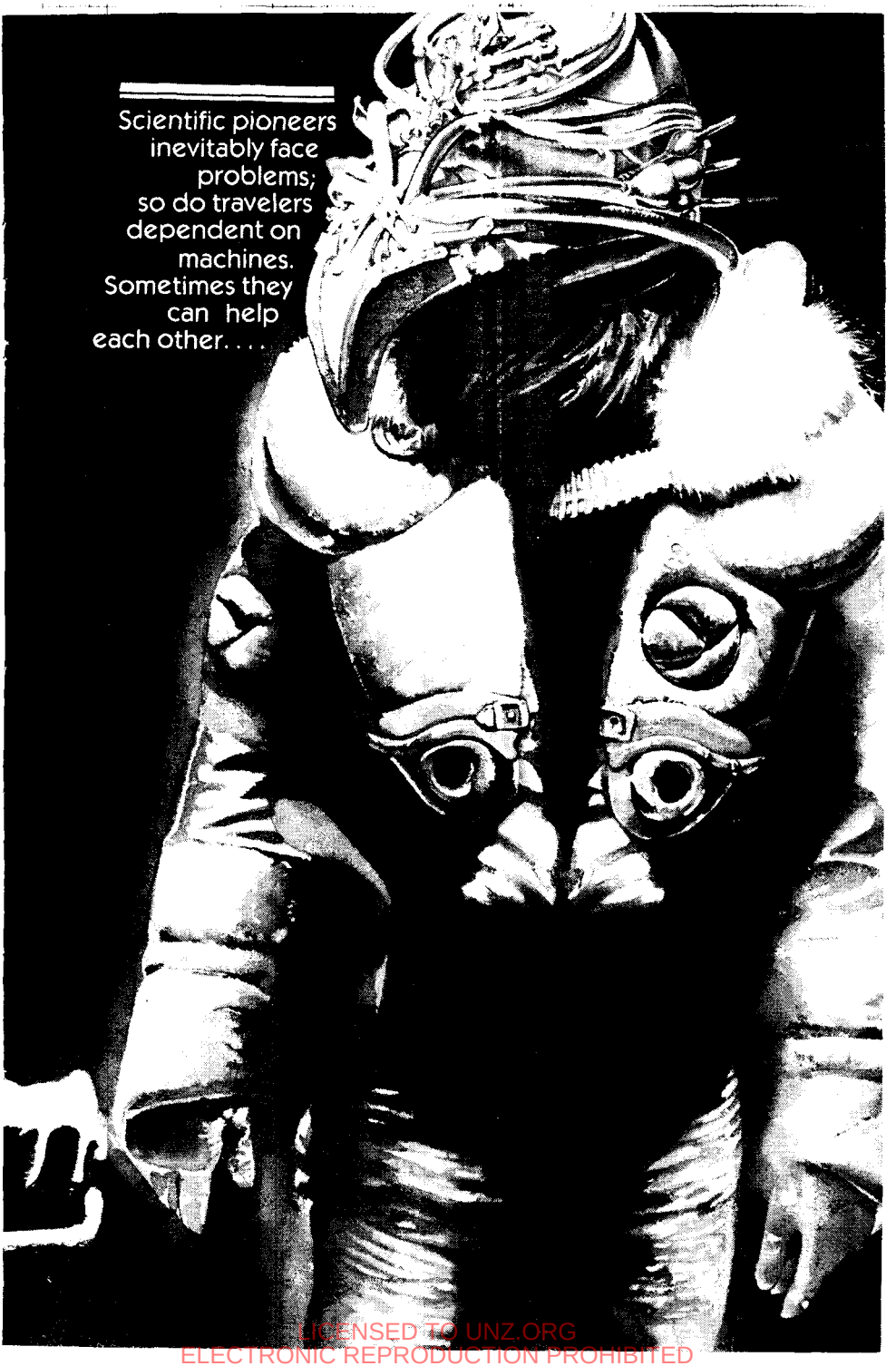
Scientific pioneers inevitably face problems; so do travelers dependent on machines. Sometimes they can help each other. . . .

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air-tight. Next he sat on the side of the casket and wondered whether he should remove his helmet. He decided to leave it on. At least for the moment he wouldn't have to make any decisions about cabin pressure and oxygen.

The alarms—all of them—had now become impatient with him. They had moved from console and wall and had invaded his guts and brain like barbed parasites. "Xeris and Mord," he groaned.

He reached for his heat-suit and simultaneously glanced at the ceiling meter. How long had he been under? Forty cycles. Long time. He closed the suit up and clumped over to the console. First turn off that *pflicht* alarm. Now back to the tail of the ship.

Air pressure apparently holding. Which meant the hole in the ship wall self-sealed in good order. The missile—a meteorite?—couldn't have been too big. So why hadn't internal automatic repair handled the problem? As he rounded the passage, the answer literally hit him in the face. A jet of oil struck his visor. The pin hackles on his neck and face stood out in panic. By reflex his hands grabbed the valve wheel and extinguished the flow. He wiped his visor with his sleeve. "By the egg that bore me!" He felt sick. How much fluid had he lost? From the looks of the balls of glop floating weightlessly around him, at least half. How was it possible? Not just one leak? He played the inspection light along the piping array. The whole tubular system was dripping. Some of the holes were big enough to see. Others were microscopic, hiding behind tiny globules of fluid. The meteorite had evidently struck a brittle section of the ship wall, which then had imploded into a thousand high-velocity fragments. He had warned Maintenance last time in. The skin was fatiguing. The chief mechanic had laughed at him.

He sighed and looked around. Oil everywhere. Mocking clusters. All sizes.

Where could he find make-up fluid in this Zaforsaken corner of the galaxy? And repair-tape? He'd used the last of his tape on the solar batteries . . . how many cycles ago?

"Khor," he muttered gloomily, "you sorry misbegotten space scavenger, you are in serious trouble." He'd have to land. Very funny. (You had to have a sense of humor for these collection missions.) To land, he'd have to find a planet. And not just any planet. One with a civilization sufficiently advanced to supply his needs.

He shuffled back through the collection area, toward the control room. He passed the cage with the ten-legged carnivorous reptile, now quietly sleeping its drugged sleep in the corner. Past the telepathic tree that had tried to charm him into its gluey branches as its next meal. Past the floating head-size ball of fluff that seemed to have no mouth, no food, and no alimentary system, but which had doubled in size since he had first captured it on Sargus-VI. And finally the empty cage: "Featherless biped." Where in the name of Xippor the Remorseless was he to find such an unlikely specimen? You can at least *try*, the Supervisor had admonished him. There are a lot of unexplored planets out there.

And so to the pilot-console, where he activated the chart screen. Nearest star . . . there we are. Yellow, medium

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size. Third generation. Has all ninety-two elements. How about planets? Big one. Too big. And too far out. Also that one with the gorgeous ring. No. The red one? No air. Next. There's one . . . plenty of water, probably good air. Life? Maybe. Civilization? Maybe. Go on. Two more. Both too hot. Back up to III. No choice, really. I'm going in.

2. Ne-tiy Introspects

Ne-tiy knelt and stared into the mirrowing surface of the lotus-pool. She liked what she saw: a young woman of excellent figure, with a face possibly bordering on the beautiful. That figure was sheathed in the classic linen tube, falling almost to her sandals, and supported by broad shoulder straps covering her breasts.

She touched her cheeks just below the eyes. There was a certain sadness about her eyes. She would like to use a little kohl at the corners for cheerful emphasis, and perhaps a little red iron oxide to highlight her cheeks, but her owner, the great priest, had strictly forbidden it. "You live for one thing, and that is not to adorn yourself." And what was that one thing? If and when the priest gave the signal, she was to offer the poisoned wine to a certain person.

She tried hard not to think about it. But it was no use. She could think of nothing else.

The priest, who served only the sun-god Horus, had bought her in the slave market at On, ten years ago. Her parents had been imprisoned for debt, and she had been turned over to the temple of the cat goddess, Bast. And then things had become blurred. She remembered she had cried a lot. Things had been done to her. In the end she knew only fear, hate, and that she was going to endure.

And then the great inquisitor priest, Hor-ent-yotf, had bought her, and had taught her certain skills. "You will enter the house of the Librarian," he had said. "You will listen to all that he does and says."

"Why, my lord?"

"Why is not your concern."

But she knew why. Hor-ent-yotf (the name meant avenger of the father of Horus) was licensed by the Greek pharaoh to sniff out heresy and impiety in the low and the high. Especially in the high, for they were the most influential. Anything demeaning the sun-god Horus was suspect. The penalty was death. She shivered.

If she were called upon to kill Eratosthenes, what would she do?

For six months she had lived as a trusted servant in his house. He knew horses, and had taught her. She had driven his chariot. He liked that. His family raised thoroughbreds, back in Cyrene, where the pasturage was rich and blue-green. When she drove with him, her body rubbed against his within the light wicker framework of the vehicle. Something had awakened within her. And now it had come to this: to be near him was torture, and not to be near him was worse.

She stared down into the pool and passed her fingertips slowly over her abdomen. "How can I ever bear his child? He doesn't know I exist. I need to be rich. I need exalted office. High priestess of some god or other. But it is hopeless, for I am nothing, and I will remain nothing."

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A shadow fell on the water. She arose and turned slowly, impassively, head bowed. She did not need to look up. She saw without seeing: the shaven bald pate, eyes lengthened by dark cosmetics, the thin pleated linen skirt with cape, the leopard skin, complete with claws, tail, and fanged, glaring head. His hands hung at his sides. Her eyes rested on his long fingernails.

On his right hand he wore three deaths, shaped as rings, each with its tiny jeweled capsule. First was the copper ring, which had a capsule shaped as Set, the god of darkness. On the middle finger was the silver ring, bearing the face of the evil goddess Sekhmet, who slew Osiris. Finally was the gold ring, on his fourth finger. Its capsule was a sardonic bow to the Greek conquerors, for it bore the face of their god Charon, who ferried their dead across the River Styx to Hades.

The faint north wind moved a sharp blanket of incense around her face. She realized that it had been the smell that had announced him.

"Where is he?" said Hor-ent-yotf.

"He has gone forth into the streets, my lord."

"When does he return?"

"In the afternoon."

"I have reason to think he has found the directions for the tomb of the heretic pharaoh Tut-ankh-amun. Has he mentioned this?"

"No, my lord."

"Be watchful."

"Yes, my lord."

"There is another matter. In a secluded courtyard at the Library he is making a measurement of the disc of Horus. Listen carefully. Let me know if he says anything about it."

"As my lord wishes." She listened to the sandals crunching away down the pea-gravel path. Then she turned back to the pool, as though trying to hide in the beauty of the flowered rim. The Greeks had brought strange and beautiful flowers to Alexandria: asphodels, marigolds, a tiny claret-colored vetch, irises purple and deep blue. Purple and white anemones, scarlet poppies.

She wished she were a simple, mindless blossom, required only to be beautiful.

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Ah, Hor-ent-yotf, great Avenger, thou demi-god, I know you well. Your mother was impregnated by the ka of Horus the hawk-god, divine bearer of the sun disc. Flights of golden hawks whirred over your house at your birth, calling and whistling to you. So it was said. As a boy apprentice in the temple at Thebes, you saw the glowing god descend from the sun, and he spoke to you. Avenge me, the god said. Find the tomb of Tut-ankh-amun, who married the third daughter of the heretic pharaoh Ikhnaton, who denied me. Destroy that tomb, and all that is within.

So it was said.

She shivered again.

3. Rabbi Ben Shem

Eratosthenes had been wandering the streets for an hour, vaguely aware of the sights, sounds, and smells of Alexandria at high noon.

The Brucheum, the royal quarter of the great city, was totally Greek, as Greek as Athens, or Corinth, or even far Cyrene, where he was born. As thoroughly Greek as the great Alexander had intended, when he strode about this shore opposite the Isle of Pharos, a bare eighty years ago and said: build the walls here, the temples there, yonder the theatre, gymnasium, baths. . . . The mole, the Heptastadia, was built from the city out to the island, dividing the sea into two great harbors. Ptolemy Philadelphus kept his warships in the eastern harbor. Commercial shipping used the western harbor.

Alexandria, the greatest city in the world, the Gem of the Nile, the Pearl of the Mediterranean, was indeed Greek. But more than Greek. All races lived here. Egyptians, of course. And Jews, Nubians, Syrians, Persians, Romans, Carthaginians. (Those last two were quite civil to each other here in the city, though several thousand stadia to the west their countrymen were happily slaughtering each other on Sicily and adjacent seas.)

He was passing now through the northeast sector, along the Street of the Hebrews. The Jews had a specially elegant quarter, a politeumata set aside for them by Alexander himself, in gratitude for their help in his Persian campaigns.

"Greetings."

He looked up. Was someone calling to him? Yes, there was the rabbi, Elisha ben Shem, coming down the steps of the synagogue. "Greetings, noble Eratosthenes!"

The geometer-librarian bowed graciously. "Peace to the House of Shem! How goes the translation?"

"Oh, very well indeed." The priest stroked his flowing silver beard and chuckled. "Why I laugh, I do not know. It really isn't funny."

Eratosthenes looked doubtful. "Well, then . . . ?"

Ben Shem grinned. "You have to be Jewish to see it, my friend. You and I converse in Greek, the tongue of the Hellenes. I am also fluent in classical Hebrew, in which our holy scriptures were written. I can also speak Aramaic and the other local dialects of Judea. But did you know there are forty thousand Jews here in Alexandria who speak, read, and write Greek and only Greek? They can't read a word of the Books of Moses, and the Psalms of David are mysteries to them."

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"I knew that," said the man of measures. "That's why Ptolemy brought seventy scholars from Jerusalem here to translate the Hebrew texts into Greek. Seventy. The Septuagint. Actually, seventy-two, wasn't it?"

Ben Shem sighed. "Ah, Eratosthenes my dear boy. So learned. So earnest. But think of it! Jews translating Hebrew into Greek for Jews. Where is the subtle sense of irony, the love of paradox, that set your ancestors apart from peasant minds? If you had your way, Achilles would overtake Zeno's hare with a single pulse beat."

"Rabbi . . ."

"Oh, never mind." He turned his head a little. "You are still attempting to determine the size and shape of the Earth?"

"Yes, still at it."

"Are you close to a solution?"

"Now, rabbi. You know I must report all findings first to his majesty."

"Yes, of course." He cleared his throat. "You will be at the palace tonight? To celebrate the coming of the Nile flood?" They stopped before the residence of the priest.

"I'll be there," said Eratosthenes.

4. The Stone Cutter

He crossed the great intersection at the magnificent mausolea. Here Alexander was laid to rest, in a marvelous glass-and-gold coffin. And in the tomb adjacent, the first Ptolemy. Beyond, to the west, lay the Rhacotis, originally the haunt of fishermen and pirates. Now, however, eighty years after the Conqueror had paced out the unborn city, it was full of the run-down shops and abodes of artisans, poets (mostly starving), and astrologers, raffish theatres, baths (some clean), slums, and certain facilities for sailors.

And so into the Street of Stone Cutters, and the first shop on the corner. He could hear the strike of chisels well before he entered the work yard. In the center, four slaves stripped to loin cloths chipped away at a copy of the Cnidus Aphrodite. The assistant project master hovered about the crew anxiously, calling, coaxing, occasionally screaming. They all ignored the newcomer. Eratosthenes shrugged and passed on into the shop. Little bells rang somewhere and the man behind the counter looked up, squinting and coughing. Stone dust had long ago impaired his eyes and lungs. "Ah, Eratosthenes," he muttered, rising. "Greetings, and welcome to my humble shop." He groaned softly as he tried to bow.

"And greetings to you, good Praphicles. I trust the gods are kind?"

"Alas, great geometer, business is terrible. When our present commissions are completed I expect that we shall starve."

The visitor smiled. Business was always terrible and starvation always lay in wait for the old fraud. Even in his semi-blindness Praphicles was still the most highly skilled of stone workers in the quarter. He turned away clients, and he owned half the real estate on the waterfront.

"Well, then," said Eratosthenes drily, "before the gods utterly abandon you, perhaps we had better conclude our business."

"Ah yes." The ancient master reached down into a cupboard under the counter,

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pulled out the work, and laid it carefully on the cedar surface.

It was a statuette of the Titan Atlas, bent, with arms arched backwards and up, as though already holding his great burden, Earth. It was cut from the famous red granite of Syene. The base held an inscription in Greek, which Eratosthenes verified by reading slowly to himself.

The old sculptor's eyes never left him.

"It is beautiful," said the visitor. "The years have not dimmed your hands, old friend. Your fingers grow even more skillful, if that is possible." He pulled a purse from his cloak and dropped it to the counter. "The balance."

Praphicles made no move toward the little leather bag. He said, "The commission was interesting, especially in what was *not* commissioned."

"You don't make sense."

"The Earth that Atlas will hold . . . where is it? Who will supply it?"

"I'll attend to that."

"And what shape will it be? He is positioned to hold a disc, or a cylinder, or a square. Or perhaps even a sphere."

Eratosthenes smiled. "How are the wagers running, good Praphicles?"

"Two to one that you will report to his majesty that the Earth is shaped like a disc. Even odds for a cylinder. Three to one against a square. Ten to one against a sphere." He pushed the bag of staters back to Eratosthenes. "Just give me a hint," he whispered. "And keep your purse."

The geometer chuckled, pushed the money back, and picked up the little statue. "I will pray to the gods to save your business, old friend."

Out again. Still walking west, and getting closer to the Eunostos harbor.

5. The Horoscope

He thought of one of the great Periclean speeches, as recalled (and probably polished up a bit) by Thucydides.

"Each single one of our citizens, in all the manifold aspects of life, is able to show himself the rightful lord and owner of his own person, and do this, moreover, with exceptional grace and exceptional versatility."

Well, Pericles, perhaps that was the way it was with you and your Athenians, but that's not the way with me. When my career—nay, my very skin!—is at risk, I feel neither grace nor versatility. I feel afraid. For I have a fair idea already how my calculations are going to come out. When I make my report, a great many people will be very, very upset. Hor-ent-yotf had warned me not to make any measurements whatever involving the sun. "It is heresy," the priest had said. "Not even a Greek under royal protection may break our religious laws with impunity."

So why am I here, in this street, at this hour? I know very well why.

But I mustn't show my anxiety. What would Marcar think? He and I studied together under the Stoic Ariston, in Athens. After that, we went our separate ways. But now here we are again in Alexandria.

Ah, Marcar, thou man of Mesopotamia, part mystic, part mountebank. Which part dominates? No matter. We have always been able to talk together.

And now it was time to be careful.

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Not against robbers or pickpockets. That wasn't the problem at all. The problem was simply this: he was now in the Street of the Mathematici Chaldaei, and he would just as soon not be recognized. What would the good rabbi say if he saw the highly rational geometer walking into the shop of an astrologer? The holy man would indeed have his cherished laugh!

Eratosthenes pulled his cloak up around his face and began walking in an anonymous shuffle. He was barely halfway down the street when small dirty urchins began tugging at his tunic. "My lord! Beautiful pictures! Naked ladies! All different positions! Mine are best! Painted directly from Ptolemy's harem. No! Straight from Eratosthenes' secret scrolls at the Library! No pictures! Real live women! No waiting! Cheap! My virgin mother! Only twenty drachmas!"

By Zeus and Hera! He struck out at them, but they scattered nimbly, like a flock of water birds.

A strong hand grabbed his sleeve. "In here, you old lecher!"

"Marcar!" He stepped into the antecourt and his host slammed the great door behind them. "Thanks, old fellow. I was coming to see you, anyhow."

"I know." He motioned to the table and chairs.

"You always say that. Actually, you hadn't the faintest idea I would visit you today."

"Maybe not today, exactly. But soon. You say you don't believe in the stars, august Eratosthenes; yet you come here because you are not completely sure. You are curious." He poured two goblets of Persian wine. "So what do you want of me?"

"Nothing. Everything."

The astrologer smiled faintly. "Translating: Does your horoscope predict anything horrible in your immediate future?"

The geometer gave him a hard look. "Well?"

"But the answer would be meaningless to you, friend, because you do not believe in astrology, or horoscopes, or star-fates."

Eratosthenes sighed. "You're right, you know. I can't have it both ways. I can't denounce horoscopes in one breath and ask for mine in the next. But it's always good to see you, Marcar." He started to rise.

The Chaldean waved him back down. "Not so fast. Tarry a bit. Who requires total belief, old friend? Not I. And what is belief, anyway? A curious mix of tradition, garbled facts, superstitition, prejudice—and once in a great while, perhaps a little truth thrown in to thoroughly confuse the picture." He sipped at his cup. "Let us clear the air. I suspected you might come. So this morning I constructed your horoscope."

The Greek looked across the table in surprise, but was silent.

"You might at least ask," said Marcar. "You owe me that much."

The librarian smiled. "I ask."

"Well, then. At the outset, please understand that a horoscope makes no absolute predictions, at least of the type you are thinking about. No chart will ever say to you, Eratosthenes, you will die at sunup tomorrow. At most your chart will say, Eratosthenes, you will be presented with the *possibility* of

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dying on such and such a day, and perhaps at such and such an hour."

"Go on," said his visitor quietly.

The Mesopotamian shrugged. "You have given the gods much trouble in recent days, and I think that even now the matter is not fully decided. I see Gaea, the Earth goddess. You would strip her naked. You would say, her size and shape are thus and so. I see Cronos, the god of time. You would have lovely naked Gaea turning, turning, turning under the lascivious scrutiny of Cronos. Apollo stands still in the skies, and leers."

Eratosthenes laughed. "What a marvelous way of saying the Earth rotates and moves around the sun."

"Ah yes. The heliocentric hypothesis. But that's only part of the difficulty. The scientific pros and cons are quite beyond me, my esteemed colleague. All I can say is, that's the problem that brings the risk. May I be blunt?"

"It would be most refreshing."

"The wrong answer to your present geodetic research may well get you assassinated."

"By Ptolemy?"

"I don't read pharaoh . . . I see a woman . . . young, beautiful, dedicated."

"So you know about Ne-tiy. Placed in my house by the Horus-priest, Horent-yotf."

"Everyone knows. The female cobra within the flower basket. Why don't you get rid of her?"

"Nonsense. He'd find someone else. Meanwhile, she's where I can keep an eye on her."

Marcar shrugged. "That's up to you, of course. But the risk to your life is not the only matter of significance. There's another thing."

"Oh?"

"You will have a visitor. A most remarkable visitor, from a place far away. I am tempted to say he is a god, but I know how you feel about the gods. Like you, Eratosthenes, he faces a great trouble. But you can help him, and he can help you."

The mathematician chuckled. "Now *that*, friend from the marshes, *is* a prediction. Years away, of course. It's always safe to predict things that happen ten years from now."

Marcar smiled. "According to the signs, he arrives on the first day of the New Year."

"There you go again. *Which* New Year? The New Year when Sirius is first seen in the dawn skies, announcing that the Nile will begin its rise? In fact, tomorrow, in the hour before sunrise? Or do you mean the New Year of the current Egyptian calendar, the first day of Thoth, which is actually two hundred days away? I remind you that the Egyptian calendar is based on 365 days, not 365 and a quarter, as shown by the stars, and that it loses one full year every 1,460 years. The last time the calendar was right was 1,171 years ago. It won't be right again until 289 years from now. So—*which* New Year, most noble charlatan?"

Marcar's eyes gleamed. "Your sign is Cancer. And however you calculate it, O great geometer, Cancer begins at midnight tonight, and announces the first day of the summer solstice. In the dark morning skies Sirius will indeed be seen, heralding the New Year, and the awakening of Hapi, which you

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Greeks call the Nile, with great festivities beginning in all towns and villages the entire length of the river, and continuing for twenty-one days, with carousing, merriment, and consumption of seas of barley beer."

Eratosthenes laughed heartily. "I take it, most astute astrologer, that buried in that Rhea-flood of rhetoric is an assertion that my relevant New Year is within the small hours of tomorrow morning, beginning with Sirius ascendant?"

"Thou seeest all, wise Eratosthenes."

"I see that you are a fraud, more colossal than any pyramid at Gizeh."

"My lord overwhelms me with his flattery." He leaned forward. "Now that your stomach is weak with laughter and your defenses breached, may we talk of your sun-project?"

"It's a bit premature."

"In any case, presumably you have by now determined the shape of the Earth? Perhaps you could tell an old friend?"

"My report goes first to Ptolemy. You know that."

"Of course, of course. Nevertheless, what harm is a hint . . . in strictest confidence?"

The mapmaker grinned. "I hear the odds are disc, two to one; cylinder, even; three to one against a square; and ten to one against a sphere." He rose to leave. "Later, Marcar. Later. I promise."

"If you live," whispered the astrologer.

The visitor stopped. He turned around slowly. "Have you drawn the horoscope of Hor-ent-yotf?" It was a stab in the dark, a flash—of what? Psychic insight? Stupidity?

Marcar peered at him most strangely. Finally he said, "Why do you ask?"

"Never mind. Really none of my affair." But he knew. The astrologer had lifted the veil on the sinister Egyptian, and he had not understood what he had seen. It was pointless to press the seer further. One thing was certain: the fates of Eratosthenes and Hor-ent-yotf were inextricably interwoven, like designs into a funerary shroud.

He bowed and left.

6. The Shadow

And so home again, away from smells and noises and dirty streets. Eratosthenes nodded to the gatekeeper and walked up the palm-lined entrance toward the central gardens. He paused under the colonnade and looked out toward the focus of the courtyard. There, as he had ordered, the scribe Bes-lek sat cross-legged in front of the shadow cast by the man-high gnomon, and he was chanting. Bes-lek had selected his own chant, a hymn, really, something addressed to Horus the sun god, a recital not too long, not too short. As the Greek watched, the clerk finished his mumbled litany, dipped his reed pen into the little pot of charcoal ink, and made a tiny dot at the tip of the gnomon shadow on the circular stone flagging. Then he commenced again. "Horus, giver of light, son of Osiris and Isis, shine down upon us in thy journey across the sky . . ." It was in Egyptian, and between the foreignness of the language and the garbled maundering, the sense was largely lost on the librarian.

Eratosthenes walked up the gravel

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path toward the chanter. Bes looked up and saw him coming, but his droning mumble did not waver. The geometer looked down at the white flagging with critical eye. Bes sat just outside a concave curve of dots. He had begun about an hour before noon, and now it was about an hour after noon. The dots showed longer shadows at the beginning, growing shorter as noon approached, then growing longer again as midday was passed. The dot closest to the gnomon base would be the one for noon. That was the one to measure. "Bes," he said, "My faithful friend, I can see from the marks that you have made a fine record of the god's overhead course. The matter is complete, except for measuring the noon angle. Get up now, stretch your legs, and then help me with the angle rod."

"Aye, thank you master." The little man groaned with great eloquence as he struggled to his feet. "Such strain, such care. My poor joints. I shall ache for days. For the pain, perhaps my lord could allot two extra puncheons of fine barley beer."

"Two?"

"One for my wife. The dear creature assumes all my pains. And considering that the festivities begin tonight."

"Two, then. Tell the steward. But first, hold the angle rod. Put the point on that inner dot, the one closest to the gnomon. Yes, that's it. Steady, while I rest the upper edge on the top of the gnomon. Fine, fine. A good angle. Now, let me take the precise measurement on the protractor arc. Yes. Seven degrees, twelve minutes, I'll take the rod."

"Is it done, master?"

"One more measurement. I need to know the distance of the dot to the base of the gnomon." He placed the rod at the base of the gnomon and alongside the noon dot. "Hm. Check me here, Bes. What number do *you* read?"

The scrivener squinted. "It is one and a quarter units, and yet it is a generous quarter."

"We'll call it one and a quarter." He doesn't ask why, thought Eratosthenes. He doesn't wonder. He doesn't care. Not one hoot of the owl of Athena in Hades. He gets his daily bread, with an occasional extra ration of beer. He has his gods and his feast-days, and he's happy. A true son of the Nile. Well, why not? It seems to work for him. He said, "Tell the guard of the kitchen I said to give you *three* puncheons of good brown khes, suitable for Ptolemy's own table. One for you, one for your wife, and one to lay on the altar of Horus, the hawk-god of the sun, who has favored us today."

Bes bowed low. "The master overwhelms me."

He's not even being sarcastic, thought Eratosthenes. "Go," he said.

And now back to the calculations. The gnomon was ten units high. The leg measurement was one and a quarter. The tangent of the sun angle was therefore one hundred and twenty-five thousandths. What was the angle? It ought to check out pretty close to seven degrees, twelve minutes. He had trigonometric tables in the library that would give the value. Check. Confirm. Recheck. Pile up the data. It's the only safe way.

Why was he doing this? Who cared whether the earth was a globe? Who

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cared what size that globe might be? Not Ptolemy Philadelphus, his lord and master, the pharaoh-god, who had brought him here to run the great library. In fact, Ptolemy had made veiled references to temple pressures. Hor-ent-yotf, the high priest of Horus, was complaining that these studies were demeaning to the hawk-deity and might even foreshadow a revival of monotheism, as attempted by Ikhnaton a thousand years ago. *That* misguided pharaoh had proclaimed, "There is but one god, and he is Aton, the sun. Pull down all other temples." The crazed pharaoh had been slain and his name obliterated from all monuments. Over the years the tombs of all his descendants, direct and collateral, had been searched out and desecrated.

All except one, mused the geometer. The boy pharaoh, who married the third daughter of the heretic. The youth had been assassinated, of course, and then properly and secretly buried, along with suitable treasures, in a hillside in the necropolis at Thebes. However, before the Aton-haters could find the grave, the tomb of the fourth Rameses was dug in the cliffside just above, and the boy-king's grave was buried under the quarry chips. Eratosthenes had seen the maps and read the reports, and then he had hidden them away.

And why was he thinking of the tomb of Tut-ankh-amun? Because it was knowledge that might save his life.

He passed on into the building and walked through silent halls into the mathematics room. Here he found the scroll of trig tables and ran his finger down the tangent columns. The angle whose tan is one hundred twenty-five thousandths. Here we are. Seven degrees, seven and one-half minutes. I was looking for seven degrees, twelve minutes. Well, not bad. Within experimental error? And how good are these tables? Some day soon, redo the whole thing. Suppose I take the average. Call it seven degrees, ten minutes, or almost exactly 1/50 of a circle. Base line, Syene to Alexandria, 5,000 stadia. So if the Earth is a sphere, 5,000 stadia is 1/50 of its circumference, which is, therefore, 250,000 stadia.

Two hundred and fifty thousand stadia.

That's what the numbers said. But was it really so? Such immensity was inconceivable.

He rubbed his chin in perplexity as he walked over to the big table where his map was spread out. His greatest work. Ptolemy himself had praised it and had accorded the ultimate flattery of reproducing the map in mosaic in the floor of his study. Copyists were turning out duplicates at the rate of one every two weeks, and probably making all sorts of errors in their haste. For which he, the author, would be blamed, of course.

He bent over the sheet.

It had been a magnificent effort, drawn mostly from documents in the library: travelers' reports (especially Herodotus'); terse military accounts; letters; local descriptions; sea captains' logs; census and tax reports. To the west, it showed the Pillars of Hercules; and even beyond that, Cassiterides, the tin-islands discovered by Himilco the Phoenician. To the east, Persia, conquered by Alexander, and on to India and the Ganges River. And beyond *that* a mythic land, Seres, where a fine fabric

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called silk was woven. Then the legend isles of Cipangu (which he didn't even show). But the whole known world, from west to east, was at most 75,000 stadia—less than one-third of the sphere he had just calculated.

And yet he knew his numbers were right.

There was more to the world than he or anyone else had dreamed.

Was the rest simply water? Vast, barren seas? Or, on that other invisible hemisphere, were there balancing land masses, with peoples and cities and strange gods? His heart began to pound. He knew it was futile to speculate like this, but he couldn't help it. Some day . . .

7. The Light

Khor sniffed the cabin air. Was it going stale? Yes, the CO_2 was definitely building. Which meant the absorbers were very nearly saturated. Why hadn't the alarm sounded? And then he noticed. The purifier bell *was* ringing. And the proper red light was flashing. Swamped by his other troubles, he just hadn't noticed. Alkali. Did he have any more? No. He remembered shaking out the last flecks of sodium carbonate from the container. He had tossed the empty box into the disposal.

Was there any chance of finding alkali down there on that watery little planet?

Conserve. Conserve. Breathe slowly, slowly. Khor, you luckless zoologist. Whatever possessed Queva to give you her sleep key? Not very smart of her.

Well, now, Planet III, just what sort of world are you? Is there intelligent life down there, waiting to hand me emergency tape, a barrel of oil (meeting hydraulic spec K-109, of course), and a basket of alkali? And (who knows) maybe they'll hand me a featherless biped as I leave.

How silly can I get?

He watched the 3-D shaper carve out a fist-sized copy of the planet sphere: blue for oceans, brown for continents, white for polar ice. He pulled the ball out of the lathe and studied it. Very, very interesting. How big? No way to tell. All he got was shape and surface. No matter. Maybe he was going to live after all. There had to be *something* down there. He put the ball in a fold of his space-jacket.

Back now to the screen.

Looking visually. Night-side. But no city lights? No civilization? Take her around again. Another orbit. Try north-south. Nothing? Not yet. Night side again. Maybe I'm too high. Lower . . . lower still. Watch out! Water! Slow down. I'm over some kind of sea. Hey—a *light!* A big one! It's a light house! Better switch on my running lights . . . what's the convention? Alternating red . . . green . . . white . . . blue. Plus a forward search beam. By Zaff, I see buildings. Spread out . . . a *city*. Saved!

Where to put down?

8. Arrival

Eratosthenes wrapped his woolen cloak tighter about him as he stared out to sea. It was the last hour of evening and the first of night. Dark sea was indistinguishable from dark sky. The constant north wind pushed back the dubious perfumes of the delta and the royal har-

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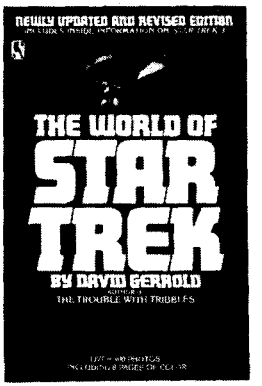

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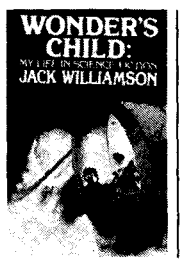

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bor, to his rear. He inhaled deeply the crisp salt air blowing in from the reefs.

He stood on the balcony of the great light house, on the Isle of Pharos, that long spit of limestone protecting Alexandria from the encroaching Great Green. He was so high, and the air so pure, that he didn't even have to use mosquito ointment.

Ah, Pharos—isle of strange and diverse fortunes! Menelaus, bound homeward from the Trojan War, blown ashore and becalmed by angry Zeus, nearly starved here, with disdainful Helen. So Homer sang. How long ago? Eight centuries, perhaps nine. But then eighty-two years ago the great Alexander came. "A fine island," he said. "It will shelter a new city, over there on the delta." He paced it out, where to put everything. Everything but the final essential building: his tomb. The first Ptolemy had built that and then had brought the body back.

"Eratosthenes," he said to himself, "you're dodging the issue. You're thinking about everything except the problem." Ah, yes. So he had confirmed (in his own mind at least) that the Earth was a sphere, with a circumference of 250,000 stadia. But it was too much. A globe that size! Incredible. Or was it? There was, of course, a rough check, available to anyone. You didn't have to go to Syene. You didn't have to look down a well at high noon, on the day of the solstice. There was another way. Just an approximation, of course.

He walked a slow circuit of the balcony, pondering vaguely the beauty of the night sea and the twinkling lamps of the city. It was lonely here, and he could think. No one to bother him. The lighthouse keepers knew him as the curator of the great Library, and let him come and go as he pleased. Far below in the courtyard Ne-tiy waited patiently with the chariot.

To the north nothing was visible except the stars and the light shaft thrusting out horizontally from the great concave mirror at the top of the tower. He had come here to think about that light beam. It was supposed to be visible out to sea for 160 stadia. To him, that was one more proof that the Earth was spherical. The light was visible out to sea to the point where the Earth's curvature shut it off. He reviewed the problem in his mind. He saw the diagram again. Circles. Tangents. The height of the Pharos tower, taken with the seaward visibility. That would give an angle—call it alpha—with the horizon. That angle alpha would be identical to the angle—call it beta—at the center of the Earth subtending the 160-stadia chord of the light shaft. The lighthouse was two-thirds of a stadion high. The sine of the angle alpha was therefore two-thirds divided by 160, or 417 hundred thousandths. Next, the angle whose sine was 417 hundred thousandths was about 14⅓ minutes, or about 1/1500 part of a circle, and finally, 1500 times 160 gave you 240,000 stadia. Close enough to the Syene measurement of 250,000. So he couldn't be too far wrong. He had done the numerical work already. He knew the result before he came out here tonight. But he still found it hard to believe. The Earth couldn't possibly be that big. Or could it? Had he made an error somewhere? Maybe several errors? Actually, the

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measurements using the lighthouse were not easy to make. Sighting the Pharos light had to be done at sea from a pitching, bobbing boat. Subtractions had to be made for the height of the perch at the mast top.

He clenched his jaw. He had to believe his numbers. He had to believe his rough check. And he had to believe the only conceivable conclusion that his calculations offered. The Earth was indeed a huge sphere, in circumference 240,000 to 250,000 stadia, more or less.

The question now was, should he so report to Ptolemy, and possibly get himself discharged from his post at the Library. Or worse?

He was due at the palace by midnight. He would have to decide within hours.

He had just turned back, to descend the outer stairway, when something in the dark northern skies caught his eye. Lights, moving, flashing. And different colors. Red . . . green . . . white . . . blue . . . flashing, on and off. And then that terrific shaft of white light . . . brighter even than Pharos . . . *coming straight at him!*

He threw his arm up over his eyes. There was a roar overhead. The tower shook. And then the thing was gone . . . no, not entirely. There it was, over the Library quarter . . . hovering now, stabbing its blinding light beam down. He raced around to the side of the light tower.

What in the name of Zeus!

Was it now over *his* house, the great manse entrusted to him by Ptolemy Philadelphus? He stared in horrified amazement.

By the wine bags of Dionysus, the thing was . . . descending into his fenced park.

For a moment he was paralyzed. And then he recovered and started down the stairs. Outside, he awoke the dozing charioteer. "Ne-tiy! Home! Home!"

9. Encounter

Khor read the preliminary data in the analyzer. Oxygen, nitrogen, air density, viscosity, temperature . . . Nothing obviously toxic. Gravity a little low. No matter. Everything within acceptable limits. He turned off the lights and got out. Fortunately for the ship (not to mention his unwitting host), he had come down in a clearing. There were trees and hedges on all sides. Tiny little things, but they would provide shelter. He had landed within some sort of private estate, and very likely he could complete his repairs without the bother of curious and/or hostile crowds. And what did they look like? If they built cities, they must have hands, and legs to get about, and certainly they were able to communicate with each other. Probably very handy little fellows.

He walked on the cropped turf back to the rear of the ship. Yes, there was the hole. He played the light on it and around it. The outer plate had laminated over nicely. Only the interior would need attention. Well, get with it. Start knocking on doors. "Could I borrow a few hundred xil of adhesive tape? And a load of high-spec hydraulic fluid (you supply the container). Plus a var of sodium carbonate. Just enough to get me to a star some nine light cycles away."

And that raised another problem. What language did these creatures speak? Better get the telepathic head-band. He

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crawled back up the hatchway and returned with it. Suppose they're unfriendly? Should I bring a weapon? No. I've got to look absolutely peaceful.

His ear tympani vibrated faintly. Noises. Wheels churning in loose gravel. Cries, addressed, he thought, to a draft animal of some sort. Two different voices? They had seen his ship come down, and they had driven here to confront the trespasser.

Fair enough. He unfolded the long veil, starting at his head, over the tele-band, and quickly draped his entire body from head down to talons. (No use alarming them right at the outset!) Then he propped up his portable beam between rocks in the clearing so that it would shine on him.

He listened to the cautious steps on the fine pebbles, closer, closer.

And there they were, two of them, standing just outside the light circle.

By the pinions of Pinar! Featherless bipeds!

One seemed calm, the other fearful and fidgety. The calm one stepped out into the light.

Excellent! thought the visitor. It has stereoscopic eyes, nostrils, mouth, ears. Not the most attractive alien he had ever encountered; yet not the ugliest, either. Somewhere in between.

Khor held up both hands to show they were empty, then bowed slowly.

The calm one repeated the gesture with great dignity.

Khor spoke through the tele-band into the mind of his host. "My name is Khor."

The Greek showed his surprise. "You understand Greek? And you are able to speak into my mind? How is this? Whence came you?"

Khor pointed to the band around his head, visible in outline under his body veil.

"Ah," said Eratosthenes. "A mental language device. Fantastic. But where—" He jerked. Strange thoughts . . . strange sounds . . . sights . . . smells . . . were forming in his head. He gasped. "You are from a distant world? A *star?*"

Khor nodded.

The geometer gulped. "Are you a god? The messenger Hermes perhaps?" (How could he be asking this? He didn't believe in gods!)

"No. I am a mortal, like yourself. My people are a little more scientifically advanced than yours, that's all."

"Why are you here?"

"I was on a collection expedition. I work for a museum, the same as you. I was searching for certain plants . . . animals . . . I was loaded up, and on my way home, when a meteorite hit my ship. I had to land for repairs."

"I see. I *think* I see. Can I help you?"

"I don't know. I will need certain things. Certain . . . tapes. Certain oils. Some . . . alkali. And then perhaps some geodetic information."

"Such as?"

"The circumference of your world, Terra, considered as a sphere."

The Greek eyed his visitor sharply.

Khor hesitated. "Have I asked a forbidden question? Is something, how do you say it, taboo? Or perhaps you were not aware that Terra is a sphere?"

"*That* I had indeed surmised. No, I was simply struck by the coincidence. I have been working on the problem for

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the past several weeks, and very recently, actually within the last few hours, I have obtained some sort of answer. But why do you need to know?"

"I can use Terra's rotational velocity to help fling the ship into escape orbit. when the time comes to leave. To determine that velocity, I need to know Terra's circumference."

"I think I can provide a fair estimate."

"Excellent."

Eratosthenes had to stop and think a moment. Khor needed the velocity of the *rotating* Earth? Well, of course. The Earth rotated. That's why the sun *appeared* to move around the Earth. But that wasn't all. The Earth must revolve around the sun, from a very great distance, once a year. And that's why the sun appeared to move through the zodiac once a year. Actually, it was the Earth that was moving. The sun stood still. The heliocentric hypothesis wasn't a hypothesis. It was a fact. And if the Earth moved around the sun, so did all the five other planets: Mercury, Venus, Mars, Jupiter, Saturn. And so the sun was a star, much like millions of other stars. Did all those other stars out there have planets, with strange life forms, thinking, working, loving? His heart beat faster as he thought about it. Whom could he tell? Nobody. "A visitor from another star told me." Next stop, the madhouse. It made him smile just to think about it.

But back to reality, and the present. "So then, Khor, can I offer you the hospitality of my house? Not a Ptolemaic palace—but yet not a hovel, either. Food of all sorts, wines brought in from all parts of the world. Baths, hot and

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cold. Servants to assist you. You could relax while we dine, and you could describe your needs to me."

"Your offer is most attractive. Truly, I have a great need. But I do not wish to cause problems for you. I read in your mind certain names: Ptolemy . . . Hor-ent-yotf . . . even the female at your side, Ne-tiy. Who are these people? How can they harm you?"

"Harm me? Perhaps the words are too strong. Ptolemy rules—*owns*—this land, called Egypt. He is a Greek, a foreigner, and he tries to rule softly, and to give no great offense to the people, aside from taking their money. But Hor-ent-yotf, a high priest of the hawk-god Horus, likewise rules, in that he reigns over the minds and souls of the people. Ne-tiy is a slave, put in my house by Hor-ent-yotf. She is his property, even as his clothing and his cosmetic box are his property. Do you read my thoughts in this matter, honored stranger?"

"I do, and I reply with thoughts. You propose to do a thing offensive to Ptolemy, and horrifying to Hor-ent-yotf, and because of this thing the priest may kill you. Or perhaps make the female kill you. Is this the situation?"

"It is so."

"I find this quite alarming. Obviously, I do not understand your ways. Please explain."

"It is a very complex matter, O visitor from great distances. Perhaps we can continue over cakes and wine?"

"Fourteen percent CH_3CH_2OH?"

"I beg your pardon?"

"Just thinking out loud. A pleasure, Eratosthenes. Just let me close up the bucket."

* * *

10. Repairs

"To each his own custom," thought Eratosthenes. "We Greeks eat while reclining on an eating couch. The Egyptians sit in chairs. But you stand."

"At all times," replied the thoughts of his visitor. "We stand to eat, drink, study, work, even to sleep. Our skeletal structure requires it." His gloved hand clasped the wine cup and brought it to his lips through a slit in his body veil.

The Greek heard a "clack" as the metal goblet struck something hard. "Well then, let us look to your needs. First, strips of adhesive cloth. Tapes, you call them. That we have in abundance. It is the custom of the country to use them as bandages to wrap the bodies of the dead, in preparation for burial." He held up a piece of white cloth. "This is a rather fine linen, woven from the flax plant. Every Egyptian family saves scraps of cloth against the inevitable burials. The pieces are ripped into strips: narrow bandages for the fingers, wider ones for the limbs and torso." He tore off a strip and handed it to Khor, who examined it closely.

"What makes it stick?" asked his visitor.

"They dip it in liquid balsam. It sets up hard in a couple of hours."

"It ought to work," said Khor. "Now, about the oil."

"We have several kinds: olive oil, from the fruits of the olive tree. It's used in cooking and in our lamps. Castor oil . . . several grades. This is from the castor bean. It has medicinal uses, and is also a fine lubricant. The army uses it in the oil packing for its chariot wheels. And linseed oil . . . which we

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boil and then use in paints and varnishes."

"Back up. This castor oil . . . is there a refined grade?"

"Indeed yes. Settled over charcoal and filtered through fine linen."

"I'd like to try that. And now one more thing. A bit of alkali."

"Alkali . . . ?" The geometer frowned.

"Sodium carbonate would do nicely. Hm. That's making it worse, isn't it? How to describe it . . . let me think. It would be bitter to the taste, very soluble in water, turns red wine blue. Fizzes in vinegar. Can be boiled with fats and oils to make soap . . ."

"Oh! Of course! *Natron!* We use it in embalming. It helps desiccate the corpse. But how would you use natron in your ship?"

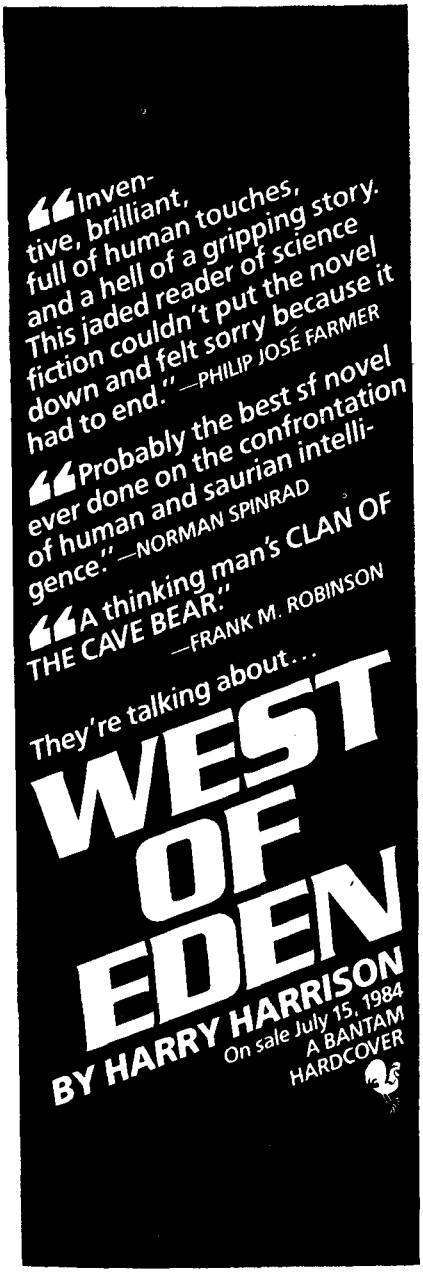
"Simple. During wake-periods on my ship, my lungs give off a waste gas, which we call carbon dioxide. It can become toxic if allowed to reach high concentrations. The alkali absorbs it."

"Well then, I think the next step is to gather up these things and take them out to your ship. I'll call the servants. No—I can't. They're all down in the city, celebrating the New Year. You and I and Ne-tiy will have to do it."

"It's just as well. Less risk to the ship."

To the extent that any of the geometer's aplomb had left him, very nearly all of it had by now returned. He said, "As you may have read in my mind, it is the practice for one of our library clerks to go through every incoming ship to look for new books to copy. I wonder . . ."

"Ah, my friend. I have dozens of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books, none in any Earth-language. *The Maintenance of Ion Drives . . . Collecting on Airless Worlds . . . Operation of the Sleep Casket.* Some with holos, for which you'd need a laser reader. But I tell you what. You like maps. Before I finally leave, I'll give you a sort of map."

"Fair enough."

An hour later Khor, Eratosthenes, and Ne-tiy had wound the last of the linen strips around the hydraulic tubes, refilled the depleted oil surge tank, and secured the amphora of natron in the storage locker.

"The balsam resin will require a couple of hours to cure and harden," said Eratosthenes. "And I am due at Ptolemy's palace very soon. May I suggest that you join me?"

"Won't I excite comment?"

"Hm. You're a bit taller than average. However, just keep covered with your body cape. I'll tell Ptolemy you're a foreign visitor and your religion requires the covering."

"Is it an offense to you, my host, that I conceal my body from you in this way?"

The Cyrenian smiled. "Since you are my guest, it pleases me that you do as you see fit." He bowed. "This way to the chariot."

11. Ptolemy on His Balcony

On this night of the summer solstice, the beginning of the three weeks of madness celebrating the rising of the river, Ptolemy the Second, called Philadelphus, stood on his balcony and looked out over the royal harbor. Shading his eyes, he could barely make out the tiny light swinging in slow arcs in the blackness. At his request, the captain had fixed the lantern at the top of the mast of the royal barge. Why? No reason given. He had simply said, do it, and it was done. Actually, it was a token of a promise to himself: tomorrow he would be on that ship, headed south on the Nile, with all concerns of state receding sternward.

For five thousand years the rulers of Egypt had made this trip. Tradition held that when the sun ceased his northward journey, pharaoh would set forth, sailing all the way to Thebes, to ensure a proper flood. If pharaoh did not thus set forth on the bosom of Hapi, the river would not rise. If the river did not rise, there would be no sowing, and no harvest. Famine would grip the land. The tax gatherers would gather little or nothing. The army could not be paid. The dynasty could fall.

Superstitious nonsense?

Who was he to say?

It was best to go along with it. Anyhow, he always looked forward to the long trip on the river. He just wished Arsinoë were still alive.

Noises in the streets below brought his eyes down to the parade of dancing torches. The annual infection had spread even here, to the guarded serenity of the royal quarter. In a way it was unsettling; yet on the whole it was reassuring that the people were content to stay within their multi-millennial rut. No riots, no revolutions, no marches against the granaries. Not this week, anyhow. Let the beer flow!

He looked around as a woman in an elegant linen dress and cape parted the hangings and stepped out to join him. A thick black wig, artfully dusted with

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gold powder, fell to her shoulders. She was his concubine of the month. Her name was Pauni, daughter of a noble house. He named them for the current Egyptian month. It was the only way he could attach names to their beautiful faces. And so it had been, since the death of Arsinoë, his true sister-wife, twenty years ago. By Greek ideas, that marriage had been incest; but it was quite in the pharaonic tradition. A bit of irony: in the river tongue, the word for concubine was "sne-t," which meant "sister."

(Ah, Arsinoë, Arsinoë. I loved you greatly. You should not have died. It was the only unkind thing you ever did.)

"Respect their traditions. Respect their religion. Worship their gods," his great father Ptolemy, Alexander's general, had told him. "Be pious. You lose nothing, and you will preserve the dynasty." He took the woman by the arm and they listened in silence to the revelry. "The old man was right," he muttered.

"Who, my lord?" said Pauni politely.

"My father. When the Persians conquered Egypt, they flouted the local religions. Ochus, the satrap, killed the sacred bull. The priests invoked a terrible curse on him, and on his masters in Persepolis. And so Alexander came, and destroyed Persia. He came to Egypt, and gave all honor to the priests. He sacrificed to Apis and other native gods. He made the great journey across the desert, without road or path, to the sanctuary of Ammon at Siwah. There the priests declared his divine descent, and that he was indeed the son of Ammon." He reflected. "Did I ever tell you about Alexander's trip across the desert to Siwah?"

(Several times, my lord.) "No, sire, I don't recall that you did."

"Ah. Well, then. The storms had destroyed the roads. Even the guides were lost. The sun was pitiless, and the men were dropping from heat stroke. But the gods sent a great flock of ravens, who flew in circles overhead, and shaded Alexander. And if the guides made a wrong turn, the birds screamed until they went straight again."

"Amazing," said Pauni.

The royal Greek sighed again. If only he didn't owe so much money to so many people. The Jews had helped him—and his father—finance the great light-tower on Pharos. It had been finished these nine years, and the treasury was still paying. And the Egyptian priests. The public debt was soaring because of their demands for new temples. And then there was the standing army, all mercenaries, and they liked to be paid regularly, in hard clanking brass. And the navy. A thousand years ago Rameses had not been troubled with ships that sailed the Great Green. And *two* thousand years ago the pharaohs didn't even use money. There wasn't any. It hadn't been invented yet. Go, said Khufu to his peasants. Build me a tomb-pyramid. One million men, working twenty years. And they had done it, and not an obol paid out to anyone. Alas, how things had changed. "Who rules Egypt?" he mused softly. "Do I? No. Do the one million Greeks who have settled here? No. Well, then, do the priests and their seven million fellahin? Or is the land a hopeless anarchy?"

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By now she was used to this. "Speaking of priests," Pauni reminded him gently, "the high priest of Horus is here. Also Rabbi Ben Shem. And then the other notables: Eratosthenes and his lady. The geometer brings a very strange guest, who covers his body with a long black veil. And then there are the consuls and ambassadors—Claudius Pulcher the Roman, Hamilcar Barca, the Carthaginian . . ."

Ptolemy suppressed a groan. Eratosthenes. He had tried to forget him, but of course it was impossible. The man of measures was going to make his report tonight. And what will you say, noble philosopher? How big is the world? As to that, say anything you like. But the *shape!* Declare Earth a flat square, or a disc, or a cylinder. Any of these. But you know you must not say "sphere" or "ball" or "globe." That's heresy, mathematician. Don't betray me, my brother Greek. There is a long line waiting to take your place as curator of the great Library. And it isn't just me you should worry about. If you say "sphere," the local holies will have you floating in the canal before the night is out.

He paused. The girl looked up at him in grave concern. He thought: she knows I am fifty-nine, and that I am dying. Ah, to be young again. No, don't turn back. Let it be finally done. Nothing really matters very much anymore. From here on in, let us have peace. He smiled. "Perhaps we should rejoin our guests."

12. Heresy

A little cluster had already formed around the two ambassadors. The Carthaginian was explaining something. "One of my purposes here is to obtain copies of the world map of Eratosthenes."

"And what good is that?" growled Claudius Pulcher, the Roman.

"Carthage will probably win our present war with Rome, noble ambassador. If so, we will expand into Spain and Gaul. For that we will need good maps. If we lose—may Baal save us!—we will certainly need to recoup our fortunes, and we would look to western Europe for that. Again, we would need good maps. Including—" (here he gave the stolid Pulcher a crafty leer) "a good showing of the passes through the Alps."

"Passes . . . ?"

"For our war elephants."

The Roman general stared at him blankly. Then recognition dawned. "Oh—you mean from Gaul, over the mountains into Italy." He began to laugh. He laughed so hard he spilled his wine. "Excuse me." He walked back to the credentia for a refill.

Ptolemy watched him for a moment, then turned back to the Carthaginian. "The great Alexander was always fearful of war elephants. He never really discovered how to cope with them. Quite an idea, Hamilcar Barca."

"But there's still a problem," said Eratosthenes. "We have several reports by travelers in the Library. They all say the passes are very narrow, barely wide enough for a horse. How will you get your elephants through?"

"You should read more of your own books, learned scroll-master," said Barca. "The mountains are made of calx. Vinegar dissolves calx. We shall

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bring hundreds of casks of vinegar. The mountains shall melt away, and the great war beasts shall pass."

"Why does Carthage disclose its strategy to Rome in advance?" asked Ptolemy.

The young Carthaginian grinned. "No harm in it at all. First, they think we lie, that we try to deceive them. Therefore, they won't bother to defend the passes. Second, they're so confident that if and when they do fortify the passes they would so tell us. Third, they are incapable of thinking in terms of empire for themselves, so they can't conceive that their enemies would have such impossible ideas. They lack imagination. They don't know what dreams are."

"They seem to have done very well despite these deficiencies," demurred Eratosthenes. "Three hundred years ago they were just a fishing village on the Tiber. Now they rule the entire Italic peninsula. Who needs dreams?"

"You have a point, mapmaker. Well then, reverse the case. We Phoenicians needed dreams, and we produced them. We have established trading outposts at the limits of the known world. We have sailed through the Pillars of Hercules to the Tin Islands. We have circumnavigated Africa. We have traded in the Black Sea. Our ships rule the Western Mediterranean, and business on great waters has made us rich. And all because we had a vision. We still have it, and with it, we shall beat the Romans."

"Peace, gentlemen," said Ptolemy. Wars and rumors of war made him uneasy. "Let us talk of other things. Eratosthenes, how go the angles?"

"Today, my lord Ptolemy, the day of the summer solstice, I measured the angle of the sun at high noon. I found it to be seven degrees and ten minutes."

The Second Ptolemy smiled graciously, yet warily, and with a warning in his eyes. "And pray what is the significance of seven degrees and—what was it—?"

"Ten minutes, my lord. Significance?" The geometer eyed the Greek pharaoh carefully. "To determine the significance, we may need the assistance of the priests"—he bowed gravely to Hor-ent-yotf and Rabbi Ben Shem—"and the historians"—a bow to Cleon, the Homeric exegesist—"and perhaps to other philosophers, living and dead."

Claudius Pulcher had meanwhile returned from the credentia with a wine refill. "Aside from all this assistance, real or threatened," he grumped, "can anyone tell me the significance of seven degrees and ten minutes?"

"By itself, nothing," volunteered Hamilcar Barca. "However, taken with certain other measurements, it could give you the size and shape of the Earth." He said to the librarian: "Am I right?"

Eratosthenes sighed, and glanced at Ptolemy from the corner of his eye.

"Oh, go ahead," said the pharaoh wearily. (And oh, to be on that barge!)

The Greek shrugged. "At Syene, where the finest red granite is quarried, a tall pole casts no shadow at noon on the day of the summer solstice, and the sun shines directly into the wells. This is so because Syene lies almost directly on the Tropic of Cancer. Also, Alexandria lies almost due north of Syene, at a distance of 5,000 stadia. Now seven degrees and ten minutes is about 1/50 of a full circle, so 5,000 is 1/50 of a full

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circle on the Earth. Thus we multiply 5,000 by 50, and we get 250,000 stadia as the circumference of the Earth."

"One moment," interposed Ptolemy. "You say 5,000 stadia. How did you measure that?"

"From cadasters—registers of land surveys for tax purposes, made by the Second Rameses, over a thousand years ago. The exact dimensions of the nomes are given. It's a matter of simple addition, from Syene to the sea, with certain adjustments."

The Roman frowned. "I still don't see. What's a 'stadia,' anyhow?"

Hamilcar Barca smiled. "The singular is stadion. A bit over eight stadia to your Roman mile. Using your units, General, the world is a sphere about 30,000 miles in circumference."

"Ridiculous." breathed Pulcher. "It can't possibly be that big."

"This is entirely unofficial," interposed Ptolemy hastily. "The Great House takes no position . . ."

Rabbi Ben Shem smiled uneasily. "Dear Eratosthenes . . . the Earth cannot be a sphere. Our Holy Scriptures state, 'the four corners of the Earth.' "

"I think we may be overlooking the obvious," said Hor-ent-yotf. "Our esteemed geometer assumes the sun is so far away that its rays, as received here, are parallel. The assumption is totally unwarranted, as I shall show. There are other, much more reasonable conditions that will give the same data." He pulled a piece of papyrus from his linens and inspected it. "If the sun is 40,000 stadia distant, it will give your same shadow angle of about seven degrees here at Alexandria, will it not, Eratosthenes?"

The mathematician smiled. "Quite so—assuming the Earth is flat."

"As is indeed the case," said the Roman ambassador.

Hamilcar Barca shook his head. "Like the Greeks, we Carthaginians are a seafaring people. On shore, when we watch a ship come in, we see first the tip of the mast, then the sails, then the bow. That means to us that the Earth is a great ball, and that the ship comes up into view over the curvature. It is the same at sea. For example, my trireme arrived here at night. We came in, guided by the great Pharos light tower. At first, our man at mast-top could not see the light at all. And then, suddenly, 'Light ho!' and there it was, just over the belly of the sea."

There was a moment's silence, broken by Ptolemy. His voice was strained. "This is a very interesting discussion; yet I do not feel that we can ignore a thousand years of research and thought that have gone into the problem. Certainly the ancient authorities leave no doubt on the question. Homer said the Earth was a flat disc, bounded by the River Oceanus. A decade before the battle of Marathon, Hecataeus announced the same fact."

"One moment, your majesty," said Hamilcar Barca. "Your own Aristotle believed the Earth to be a sphere because of the round shadow on the moon, during lunar eclipse."

Ptolemy shrugged. "Homer's disc, head-on, would cast a round shadow."

"My lords," said Rabbi Ben Shem harshly, "I make no attempt to define or deal with impiety. Certainly Greek history provides ample precedent. I have read widely in your Library, Er-

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atosthenes, and I can cite your own laws and applicable cases. Your Anaxagorus propounded a heliocentric system, and wrote that the sun was a big blazing ball, bigger even than the Peloponnesus. He was condemned to prison for his impiety. Pericles was barely able to save his life. Aristarchus also proposed a heliocentric cosmos, and was accused of impiety. Alcibiades was recalled from the Syracuse campaign to face charges of impiety to Hermes: whereupon Athens lost the war. Socrates was executed for impiety. Protagoras confessed agnosticism and fled Athens with a price on his head."

Ptolemy rubbed his chin. "I, for one, believe Homer, who declared the Earth to be flat, with its omphalos—navel—at Delphi. A sphere seems quite impossible. People at the antipodes would walk with their heads hanging down. Trees would grow downward. Rain would fall up. These things cannot be." He fixed a grim eye on Eratosthenes. "The gods gave us a flat world, my young friend. Adjust your numbers to fit the facts, not the other way around." And so having delivered his views, and having thus dried his throat, he and Pauni left the group in search of the wine table.

"Well, then, man of the Library," said Ben Shem, with just a hint of triumph, "you will of course recant?"

Eratosthenes found his body turning, not to face the rabbi, but instead to Hor-ent-yotf. It was to the priest of the hawk-god that he gave his answer: "No. I do not recant. I do not retract. It is as I said." The hawk-priest stared at him without the slightest expression.

"Oh!" said Ben Shem. "You claim the Earth is a sphere?"

"Yes."

"And it circles the sun?"

"Did I say that? If I didn't, I meant to."

"Aiee!" shrieked the rabbi. "Heresy, heresy compounded!" He pulled at his beard, and a few hairs tore loose.

"Sorry," said the Greek apologetically. "I didn't know you'd take it this way."

The priest stumbled away, muttering.

Khor shot a thought into the geometer's mind: "Science is a very upsetting subject around here."

"Yes."

Hamilcar Barca broke in. "May I ask a question about your 5,000-stadia measure to Syene?"

"Of course."

"Does that include a rake-off by your local priests? Say, one-sixth?"

"How do you mean?"

"Well, suppose the true measurement is actually 4,285 stadia. Do the priests add one-sixth, or 715, for their share of the grain crops?"

"Yes." It was Hor-ent-yotf who answered. They all looked around at him. "From the time of Menes," said the priest, "the first pharaoh, who united upper and lower Egypt, the temples have taken one-sixth of the crops. We do this painlessly, by telling the farmer his plot is one-sixth larger than it really is."

Eratosthenes was embarrassed. "I am caught in a gross error. The circumference is then 4,285 times 50, not 5,000 times 50. More accurately, the circumference is—" he thought a moment—"214,250 stadia, or about 26,000 Roman miles."

"The one-sixth difference is not sig-

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nificant," said Hor-ent-yotf. "The crux of the matter is, you have attempted to heresy of the gravest order." He signaled to Ne-tiy. She glanced once at Eratosthenes, then followed the hawk-priest away from the group.

"Watch him," warned Khor. "I see into his mind. He has condemned you, and he means to kill you."

The geodesist shrugged. "It had to come."

"Shouldn't you leave now?"

"Why delay the confrontation? It might as well be here. Regardless of what happens to me, Ne-tiy can drive you back to your ship."

"I wasn't thinking of that. When the time comes, I can manage by myself."

"Can you see them?" asked Eratosthenes. "You are taller."

13. Something in the Wine

"I see them both very well. He and the female approach the wine table. He whispers to her. She is to put something in your wine."

"Poison."

"Yes. You are to die by poison. The mind of the female is in a great turmoil. She wants to refuse. But the priest threatens her. Ah, she looks back this way, but she cannot see you. What a strange expression on her face, Eratosthenes. How is one to interpret it?"

"Horror, possibly. She does not really want to kill me. She resists strongly, but I think probably she will make the attempt. From childhood, this is what the temple trained her to do."

"They argue some more. He insists. He says to her, if she fails, servants will bind her mouth and limbs, and carry her in a cart to the temple pool, and the crocodiles will feed. And you will die in any case."

"Pleasant fellow."

"Perhaps you should leave with me, Eratosthenes. As you know, I still seek a bipedal specimen. On my world you need have no fear of assassination."

The librarian laughed forlornly. "Don't tempt me, admirable visitor. What are they doing now?"

"Nothing as yet. I am in the mind of the priest. He is thinking about rings on his fingers, and three white powders. Arsenic . . . strychnine . . . aconite. Arsenic is tasteless, but takes a while, probably too long for what he wants. Also you might get sick and vomit. Strychnine? A good one. Not much is needed. Acts in a few minutes. Whole body goes into mortal spasm. He's seen a man die, lying flat, resting only on his heels and the back of his skull. But strychnine is bitter. You might taste it and not drink the wine. No, no strychnine for you. It's aconite. The deadliest known poison. It is extracted from a delicate plant that looks like a tiny helmet or hood, and which grows in mountains called the Alps, far to the north of the Roman domains. A crystal the size of a grain of sand can be fatal. You are quickly paralyzed. Your heart stops. Death is quick. Ah, he's moving. He cups his hand over a wine goblet. The cap on his golden ring opens. A powder falls into the wine. He gives the goblet to the girl. He snarls at her, and she moves away. Look sharp, Eratosthenes! Here she comes!"

And there was Ne-tiy, standing before him quietly. "I have brought wine, my lord."

He looked at her in glum silence.

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She raised the cup to her own lips.

"No!" he cried. He struck the cup away. It clattered to the floor, splashing red liquid over carpet and guests, who stared around in dismay. "Sorry!" cried the geometer. "So clumsy of me!" He called a serving man to bring mop and bucket.

Ne-tiy had not moved. "True, my lord, I could not harm you. Yet, what you have done to me just now is a cruel thing. For now I face a very painful death. The wine would have been . . . like going to sleep."

"Khor, take care of her for a moment." His voice grated harshly in his own ears. "Take her out on the balcony. I'll join you there in a little while." *Now, Hor-ent-yotf, you son of river scum, where are you?*

14. The Bargain

He found him quickly. If Hor-ent-yotf was surprised, he didn't show it.

Eratosthenes controlled his voice carefully, as though he were discussing the weather, the cost of grain, or whether the eastern harbor might need dredging this year. "I understand that Ne-tiy has refused to kill me. This despite your direct order. So that now her own life is forfeit. Is this not so?"

"Why should I stand here, talking to a Greek spawn of Set? Yet it is so. She failed. She dies."

"Let us bargain, high avenger of Horus." Should he include his own life in the negotiations? No. Too demeaning. Just Ne-tiy. He said, "I will buy her."

"Ah?" The small eyes peered suspiciously at the heretic. "With what?"

"Information. I know the burial site of the boy-pharaoh, Tut-ankh-amun."

The eyes of the priest popped. "You lie! You lie most vilely!"

Eratosthenes smiled. "No. It is so. Tut, son-in-law of that great heretic, Ikhnaton, who decreed the worship of Aton, the sun, and desecrated all other temples. Ikhnaton, who built Akhetaton, an entire city, devoted to the worship of Aton . . ."

"The City of the Criminal!" breathed the priest. "He died. And we destroyed his city. We destroyed everything of his. All—"

"Except the tomb of Tut . . . who married Ikhnaton's third daughter."

"Prove it!" hissed Hor-ent-yotf. "Prove you *really* know!"

"I have seen the records. The report, for example."

"Report? What report?"

"The one written by the captain of pharaoh's guards. He caught the grave robbers in the act of breaking in. He slew them on the spot, reinforced the entrance, and posted a guard."

"Go on."

"I can give you the record of the final funerary banquet, held within the tomb itself. Eight necropolis officials ate five ducks, two plovers, a haunch of mutton. They drank beer and wine, and they swept up all residue with two small brooms, put the debris in a special jar, and buried the jar in a pit outside the tomb. I have seen the jar."

The Avenger of Horus studied the librarian, and his eyes narrowed in a crafty squint. "How much can you tell me about the location?"

"It's in the Necropolis of Thebes, in the Valley of Kings."

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"Hm. That's a big place. Specifically—?"

"No specifics as to place until we have an agreement."

"I see. His queen, the vile spawn of the criminal pharaoh Ikhnaton?"

"Her name was Ankhesenamun. But she was not buried with the boy king."

"Interesting." The priest hesitated. "But certainly the tomb was re-entered subsequently?"

"No. The entrance was later further sealed, one might say almost by accident. I have verified that the seal is undisturbed."

"The last of the Atonist hell-people," muttered the priest. "Pull him out of his death-lair. Burn the infidel mummy. The gold and silver go to the servants of Horus."

"Is it a bargain?"

The holy man hesitated. They both waited for a time in silence.

Eratosthenes sighed. "The excavation will be expensive. A hundred slaves must be rented and housed and fed for several weeks. You will need ready money. I will sign over my Cyrenian estates to you, together with my gold on deposit in local banks."

Hor-ent-yotf still seemed lost in thought.

"If we cannot agree," said the librarian gravely, "I will be forced to take a certain action."

"Oh, really?" The priest's mouth curled. "Exactly what?"

"I will turn over Tut's location to the Council of Antiquities. They will excavate at government expense. There will be great excitement, presaging a revival of Aton-ism."

The priest clenched his fists. "You wouldn't!"

"I would."

"Yes, Greek, I think you would . . . for you are the ultimate obscene evil . . ."

"Well?"

"But hear me well, son of darkness. We speak only of the faithless slave girl. What Horus intends to be *your* fate, only the god can say."

"Such is my understanding."

"Then consider it done." The priest struck his chest with his fist. "I will have the temple clerks draw up the agreement, in hieroglyphics and in Greek, and I will come with it to the Serapeum tomorrow afternoon. We will sign before witnesses."

"Yes." Eratosthenes turned back toward the balcony. The priest hesitated for a moment, then followed at a dozen paces. He swirled his cloak about him as though to minimize contamination from the air the Greek passed through.

15. Sirius Rising

As he stood on the balcony with the girl, Khor found himself thinking of Queva, and Ne-tiy, and how they seemed to blend into one person, one passionate loving mind. "I will wait for you," Queva had said.

He had followed closely the negotiations between Eratosthenes and Hor-ent-yotf. Ne-tiy had saved the Greek's life at apparent cost of her own, and now the man had given up all that he had to save her. Khor would not have believed these creatures capable of such nobility. But there it was. Strong stuff. How was he going to enter this in the ship's log? The Supervisor would nei-

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ther believe nor understand. So skip it all. Maybe tell Queva someday.

I'm very nearly done here, thought the star-traveler. Just one more little job. Ah, come on out on the balcony, Eratosthenes. And here comes Hor-ent-yotf, right behind you. That's good, very good. He shot a thought to the Greek: "Dawn is coming, friend. Look, there's my home star—rising just over the sea!"

"Sirius?" said Eratosthenes, pointing.

"Sothis!" said Hor-ent-yotf, giving the Egyptian name for the great blue star.

Khor spoke again to the mind of Eratosthenes: "Your Sirius—my home star. And a fine conclusion to a profitable visit. You see the first heliacal rising of Sirius, or Sothis, and you tell me that means the Nile has now started to rise. It means the summer solstice, and great festivities throughout the land, going on for days. Thank you for all your help in repairing my ship, and for your contributions, including this last."

"Our pleasure, esteemed visitor!" Then he stopped. "This . . . last?"

"Especially this last," replied Khor cryptically. "It is time for me to go. If I launch within the next few minutes, my trajectory vectors out directly toward Sirius."

"I'll call Ne-tiy, and she'll run you over to your ship." He was still puzzled.

"No need. I know where it is."

"But how—?"

"Ah, my friend, I see you really didn't know. Well then, in view of what is about to happen, perhaps you should have some important witnesses. Get Ptolemy and one or two others. Quickly now."

Eratosthenes felt a lump of cold lead forming in his stomach.

"Hurry!" said Khor. Through the black body veil the command burst like the hiss of the great gyrfalcon.

Gods! thought the Greek. That was an actual shouted command! He's vocalizing! The librarian sliced through the balcony drapes and stumbled into Claudius Pulcher, arm in arm with Ptolemy. "My lords," he gasped, "could you please join me on the balcony?"

"What's up, Eratosthenes?" demanded the Greek pharaoh. "Oh, I know—Sirius is now visible? Is that it?"

"Majesty, if you please . . ." Eratosthenes pulled the drapes aside.

A little crowd was already gathering: Pauni . . . Hamicar Barca . . . a dozen gilded dignitaries.

The tall shrouded figure faced them all, then bowed especially to Ptolemy. "Thank you for a pleasant evening, ruler of Egypt," he said in harsh sibilant tones. He took his shroud with both hands and in a smooth majestic motion pulled it away from his head and body, then let it fall to the floor.

They stared.

The great head was entirely feathered. The mouth was an amber beak. Feathers scintillated on arms and chest. Some sort of breech-clout covered the groin. The legs terminated in scales and in what were almost human feet, except that the toes were taloned. As in the raptor birds of the Nile, a horizontal fold over each eye gave the face a stern, even fierce expression.

Eratosthenes now realized that the

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outlander was a consummate actor, that every word, every gesture, was planned for its dramatic effect, and that this terrified audience lay in the hands of Khor.

The mystery-creature now made his feathers vibrate, so that they excited nearby nitrogen atoms, and surrounded his plumaged body in a golden triboluminescent glow.

Ptolemy dropped his wine cup. Even Eratosthenes, who had suspected something like this would happen, was stunned.

"Horus!" gasped Hor-ent-yotf. "*Thou art the god!*"

"Thou sayest, worthy Hor-ent-yotf," hissed the visitor.

"To your knees, everyone," roared the priest.

And so they did. With one exception. Rabbi Ben Shem tore his cloak and ran screaming from the room.

Khor looked full at Hor-ent-yotf. "Come."

Hor-ent-yotf rose and walked forward, as though tranced. Khor took the man in his arms. "Arise, all, and witness," he commanded.

Gigantic wings unfolded from Khor's shoulders. The spread of those great pinions exceeded even the breadth of the balcony.

And now even Eratosthnes was done in. He pronounced slowly, quietly, and with great conviction, his favorite schoolboy oath. "Holy . . . excrement . . . of Zeus!"

Khor ignored him. "Since I take with me this holy man, I must appoint and sanctify a person to take his place, and to rule my holy temples in his stead. I name Ne-tiy. Come forward, child!"

They made way for the slave-girl. She bowed before the winged thing.

"I name thee High Priestess for Horus, for Egypt, and for all the world, exalted above all men, above even my noble son, the pharaoh Ptolemy. Take thee to mate whom though wilt. Be fruitful, and be merry. I go."

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He held the priest with one hand and tossed something to Eratosthenes with the other.

Next, there was a tremendous rush of air from the fantastic wings, and the giant birdman leaped over the balustrade and was gone.

Eratosthenes watched for a moment. At least the coursing creature was headed in the right direction.

Should he feel sorry for Hor-ent-yotf? He decided that maybe he should. However, he didn't. A character flaw, possibly. But who was perfect?

The rest of them joined him at the parapet. All eyes were looking out over the city, searching the skies. And now a collective gasp. "There!" cried someone. "The chariot!" shouted another. "See the lights!" "Straight into the rising sun!"

He turned away and hefted the strange ball Khor had thrown to him. No time now to study it in detail, but he knew intuitively what it was: a model of the Earth.

He raised his eyes. Ne-tiy was standing at the entrance-way, looking at him. The geometer walked toward her. "How it is on *his* world, I do not know. But in Greek lands, the man takes the woman, though she be exalted, and of the highest rank. And so I take thee, Ne-tiy."

She gave him a sweeping bow and a most marvelous smile.

16. The River

"I hope the Horus affair has taught you a lesson," said Ptolemy. "I think you must now be quite convinced."

The two couples rested under the rear canopy of the royal yacht, which was moving upriver with its great red sail stretched tightly by the north wind. Pauni and Ne-tiy were immersed in private murmurs while the men talked intermittently.

"I have learned much," admitted Eratosthenes.

"For myself," continued the Greek pharaoh, "I never had any doubt that the gods were real. It is a bit puzzling, though, that the god would take that priest. I never thought much of Hor-ent-yotf. Always considered him a dangerous fanatic. Shows how wrong even I can be."

"A memorable man," murmured Eratosthenes.

In silence they watched a riverside village pass. The river had now risen to the stage where the house-clusters were accessible only by causeways and moles. The brown people had drawn back into their reed and wattle cone-roofed huts to let father Hapi drop his bounty. In a couple of months the waters would recede. The farmers would sow their wheat and barley, and finally they would reap. Four months of flood and receding water, four months of sowing and growing, four of harvest and drying up. Then repeat. And repeat. They had been doing this for more than fifty centuries. From time to time conquerors had flowed in, then out again, like waves on the seashore. Nubians . . . Hyksos . . . Assyrians . . . Persians. And now the Greeks. A million Greeks, up and down the river. How long would *we* last? Who throws *us* out? Rome? Carthage? "Majesty," said Eratosthenes, "what happened to those two ambassadors?"

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"Interesting, that. They both got word that Panormus, on Sicily, fell to the Roman besiegers. Barca was recalled to Sicily to organize the Carthaginian guerrillas. Pulcher will return to Rome to organize an army to fight Barca. It's all insane, isn't it? What will they do with Sicily? Who cares? But Sicily isn't really the point, is it?"

Eratosthenes shrugged. "No. Actully, there are two points: one is greed, the other conquest. If Carthage wins, her greedy ships will sail west to Cipangu . . . the Indies . . . perhaps in our generation. They sail for trade and profit. If Rome wins, we will not see the antipodes for a thousand years. They go nowhere they cannot conquer. And they move only on roads."

"I fear I must agree," said Ptolemy. "We Greeks used to go out to colonize. But that spirit is dead. It died five hundred years ago." The pharaoh's nose twitched. He looked back toward the incense tripods on the stern of the yacht. "We cover the smell of death with other smells." The braziers burned balsam, carnation, anise, and the blossoms of assorted flowers.

Eratisthenes smiled. He didn't really care for the artificial smells either. Actually, he preferred the river odors: willows, reeds, orchards, palms, fish (living and dead), the dung of humans and beasts, all veneered by this massive rising water and its suggestion of distant melting snows. He studied the beads of condensate on the chill sides of his silver goblet.

Ptolemy was watching him. "It's cooled with crushed ice. Improves the tang and fights the heat. The locals prefer their beer warm. Do you realize they have never seen ice? They don't even have a world for it in their language."

"Curious," said Eratosthenes absently. Ice . . . snow . . . he mused. I made a special map of the Nile, beyond the cataracts, south to the confluence of the Blue and White Nile. Melting snow . . . that's what starts the yearly flood. Snow on far, equatorial mountains. Vast mountain ranges, far to the south. And feeder lakes. Big ones, inland seas. Some day we'll find them.

Ptolemy squinted around toward the ladies. "The priests are putting on quite a show at Thebes, in the great temple of Karnak. We would all be honored if the Betrothed-of-Horus could open the ceremonies."

"So it is written," said Eratosthenes gravely.

"Good. Settled. Religion, true religion, keeps a country alive, don't you agree, dear Eratosthenes?"

"Oh, quite."

"You've read Herodotus, of course. You recall that the Greeks at Marathon called on the great god Pan to terrify the Persians, and he did, and we won."

(Not to mention, we had a very smart general, thought Eratosthenes.)

"And you know," continued Ptolemy, "that Athena herself saved our fleet at Salamis. She was actually seen to alight on the prow of Themistocles' flagship."

"So I recall."

"So then, quite aside from the appearance of Horus last night, it is plain that the gods exist, and have been with us from the beginning. Clearly, they control human affairs. We must yield to the gods in all things, Eratosthenes. When science and religion conflict, sci-

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ence must yield."

Ptolemy took the geometer's silence for assent. "Did I ever tell you of the great Alexander's journey to the shrine of Ammon, at Siwah?"

(Many times, thought Eratosthenes.) "I don't seem to recall . . ."

"Well then. My father, the first Ptolemy, told it to me. Storms had completely obliterated the desert roads. Nothing to be seen but a sandy waste. The priests wanted to turn back. 'No,' said Alexander. 'If I am truly a natural son of Ammon, the god will send a guide.' And no sooner than spoken, here were these two serpents, rising out of the hot sands. 'Follow us,' they said, and off they went . . ."

(Wasn't it two ravens last time? thought Eratosthenes.) "Amazing," he said.

"He said to her, 'Be fruitful; be merry.' "

The map-maker had to think a moment. "Yes, the god Horus, to Ne-tiy."

"Not to you, though, Eratisthenes. Nothing merry about geometry."

"No."

"My father knew Euclid, who wrote his Elements back there in Alexandria. Father tried to plow through the Elements. Tough going. Complained to the master, there should be an easier way. Euclid replied, 'My lord, there is no royal road to geometry.' Father was so impressed that he founded the chair of mathematics at the Library. We've had a world-renowned geometer there ever since. Including you, young fellow."

"I am honored. And grateful."

"Actually, things turned out rather well for you."

"Yes."

To their rear the young women were talking in low tones. He heard a strange tinkling sound, as of little silver bells. He started to turn, then stopped. He knew what it was. Ne-tiy had laughed. He had never heard her laugh before. He relaxed and looked out over the river, to the west. The sun was a glowing semicircle, growing smaller and smaller as it dropped below the darkening hills.

"Gizeh," said Ptolemy, shading his eyes as he pointed into the sunset. "Have you ever seen the pyramids?"

"Yes, sire. But perhaps the ladies . . ."

The two women were already at the rail, looking out over the distant sands. The men joined them. They were all thralled to silence by the three immense structures.

Egypt, O Egypt, thought Eratosthenes. Land of cyclopean architecture and bestial gods. Where does awe leave off and disgust begin?

Twilight was brief. The sailors were already lighting lamps along the ship's walkways. Upriver, along the shore, more lights were visible. Torches, thought the mathematician. A lot of them. And the sound of sistra and tambourines, with shouting and singing and much merriment. The whole city was turning out to greet the pharaoh.

"We're coming into Memphis," said Ptolemy. "I'll have to join in the temple ceremonies, and Pauni and I will sleep in the palace tonight. You can join us, or you can remain on board."

"If it please you, we'll stay."

"I thought you might. You and the priestess may have my quarters. Everything is prepared. Until tomorrow, then."

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17. Khor's Globe

Ne-tiy watched with uneasy curiosity as Eratosthenes opened the chest and carefully removed the little statue of Atlas, his back and arms still bent to receive his as yet invisible burden.

"I see writing on the base. An inscription in Greek," she said. "What does it say?"

"It says, 'Tell my friends I have done nothing unworthy of philosophy.' - Hermius."

"What does it mean? And who was he, this Hermius?"

"Hermius was a Greek who studied with Aristotle, under Plato. He was captured by the Persians and tortured. He said these words, and then he died."

"I see. You admire him."

"Very much." From another compartment he pulled out the ball that Khor had tossed to him on the balcony. Bigger than his fist, smaller than his head. It fit exactly on the titan's back.

"What is *that?*" whispered Ne-tiy.

"The world globe. Khor made it, and gave it to me as he left."

They both studied it in silence. It was clear she did not understand. Perhaps it was just as well. He was not sure *he* understood. It might have been better if Khor had never come. No, that wasn't so. He was very lucky that Khor had come.

But this globe . . . the artifact was far ahead of its time.

(She stole an uneasy look at his face.)

My great world map, he thought, over which I have labored so many years . . . compared to this it is almost nothing. A bare 80 degrees out of 360. We have not even scratched the surface. Most of the world is still out there, unknown, undiscovered. Who will be the first to find it? I wish I were a great sea captain. I'd take a dozen ships. Sail out through the Pillars of Hercules. Due west. Into the western hemisphere. And there meet those two great continents. How to get around them? Perhaps a northwest passage through the north polar sea? Or around the southern tip of the southern land giant? And then on, for a complete circumnavigation of the globe.

He sighed. Not in his lifetime. Perhaps not in a hundred years. Maybe not even in a thousand. But eventually ships would go forth to that new land. And find what? Cities? Savages? Strange animals and plants? No way to tell.

Back to Earth, map-maker! He pressed the globe's north polar cap with his index finger. There was a click, and a tiny spot of light began to pulse, on and off, on the facing side of the sphere.

Ne-tiy gasped. "What is that?"

"The light simply marks the spot where we are. See?" He pointed. "We are *here*, at Memphis. See the river? Yesterday the light point was on Alexandria, on the Great Green. In five days it will be at Thebes. Calm down, it won't hurt you. Down here is the rest of Africa. Above, Italy, Gaul, Iberia, the Tin Islands, Thule. East, India, Seres, Cipangu."

"Are there really such places?"

"Yes. Do you want to see the other side?"

" . . . I don't know."

"Well, then, we won't look."

"Can you turn off the little light? It's like the eye of Horus, watching us."

He laughed, but turned it off. "You know what Homer said."

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"What did Homer say?"

" 'Though all gods and goddesses look on, yet I gladly sleep with golden Aphrodite.' "

"I have a better one," said Ne-tiy. (For she knew she held the ultimate refutation of all science: geodetics . . . math . . . cartography . . . the rising of stars . . . the solstice of suns.) "*Aie se philo*—I love thee forever." She held out her arms. ■

ROGUE'S GALLERY

The strangler strokes his silken cord,
The mugger loves his knife.
The poisoner makes his victims twitch,
And thrash away their life.
The passionate choose bullets,
Or perhaps a heavy club
While some are more inventive,
They electrify a tub.
But the ones that give me nightmares,
And destroy my aplomb
Are those smiling men in politics,
With their damned atomic bomb.

P. M. Fergusson

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Margaret L. Silbar

BORN-AGAIN IDEAS

Conceiving a new idea is one thing (and not very easy). Making it take root and grow is quite another.

"Every art possessed by man comes from Prometheus."

It seems appropriate to begin a piece about ideas that are born before their time and later come around again by turning to the verse "Prometheus." In it the playwright Aeschylus celebrated the triumph of science which transformed life in Athens during the 5th century B.C. The verse opens as Zeus has chained Prometheus to a rock to punish him for bestowing the gift of fire on mankind. As it proceeds, the Titan lists the many other gifts he has given man.

No one would claim all of our modern-day science and technology as a gift of the Greeks. But as one physicist looks at Greek science, he concludes that "the inner logic of scientific patterns of thought has remained unchanged by the passage of centuries and the coming and going of civilizations: the same models and associations recur, only in new forms suited to the more advanced stage reached by physical knowledge."[1]

Indeed, there seem to be a surprisingly large number of physical ideas which were bestowed on man, then lost and later re-born. John von Neumann, who godfathered the electronic computer, once remarked that "by and large it is uniformly true in mathematics that there is a time lapse between a mathematical discovery and the moment when it is useful; and that this lapse of time can be anything from 30 to 100 years, in some cases even more; and that the whole system seems to function without any direction, without any reference to

[1] S. Sambursky of the Hebrew University of Jerusalem in *The Physical World of the Greeks*.

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usefulness, and without any desire to do the things which are useful." Likewise in all science.

Aristarchus conceived the notion of the heliocentric theory; it was re-born to Copernicus, whose models bore a striking similarity to those of the Arab Ibn-al-Shatir. Einstein invented the crucial concepts needed to make a laser; it only emerged in the 1960s when enough other physicists had "seen the light." The very recent idea of a modern-day force which increases with distance was discussed at length in the 18th century by the Jesuit scientist Roger Boscovich. A patent for the transistor was granted in 1930, but the invention that was 26 years later to produce a Nobel Prize went unnoticed. . . .

Maxwell wrote about feedback as a self-regulating mechanism; the idea 80 years later led to the founding of the science of cybernetics. Blaise Pascal is credited with the discovery of mathematical induction as a formal proof; the man known as "the reckoner of Egypt," Abu Kamil Shuja Ibn Aslam, used it at the time of Christ. The method for calculating square roots born to William Horner in 1819 was known to the Chinese as early as the Han dynasty. Between 206 B.C. and 221 A.D., the Chinese had in fact extended this method to solve first quadratic and later higher numerical equations. . . .

It would seem as if *almost all* ideas can be traced to another time, another place, another culture. Using an extreme example, one can even trace Sadi Carnot's notion that potential energy turns into kinetic energy to Aristotle, and that of gravity to Nicolas of Cusa. It is interesting that sometimes good ideas have to come by our blinded eyes a number of times before they are recognized as such. In this article I will discuss in some depth a few of the more interesting examples of born-again ideas: winged flight, the Moebius strip and projective geometry, antimatter and the black hole, the telescope, the steam engine, and finally, the hollow Earth.

Winged Flight

Prometheus "constructed wheelless vehicles with linen Wings to carry them over the trackless waters."

Sometime between 1000 and 1010 A.D. Eilmer of Malmesbury, an Anglo-Saxon Benedictine monk, fastened rigid wings to his hands and feet so that "mistaking fable for truth he might fly like Daedalus." Jumping from the abbey's tower and collecting the breeze, he flew more than 600 feet before falling and breaking his legs. The cause of his failure, he said, was simple: he forgot to put a tail on the rear of what was essentially the first glider.

Eilmer is the first Westerner to have flown successfully.[2] He was, in fact, remembered throughout the Middle Ages and the Renaissance. In 1260 Roger Bacon insisted that "flying machines can be constructed so that a man sits in the midst of the machine revolving some engine by which artificial wings are made to beat the air like a flying bird. . . ." And, he said, he knew

[2] In 875 A.D. it was said that in Andalusia a certain Ibn Firnas "flew faster than the phoenix in his flight when he dressed his body in the feathers of a vulture."

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someone (presumably Eilmer) who had done it. Eilmer's wings may have been intended to flap but, speculates the historian Lynn White Jr., were probably "hinged in such a way that they would not fold upward but would soar like a glider." In the West, however, everyone appears to have been blinded by the idea of flapping wings.[3]

The great development of gliding—and hence the Wright brothers' success—rests on observations of kites in flight. The kite, needed to study air currents, had been used in China since at least Han times; one story has it that a general used it for reconnaissance. The first word about kites to reach Europe appeared—not surprisingly—in Marco Polo's account of his East Asian travels. This amazing Italian traveler lived from 1254 to 1324 and is said to have revealed on his deathbed that he did not tell half of what he had seen because he knew he would not be believed. One tale from the Latin version of his memoirs in the cathedral of Toledo: when a merchant ship was about to start on a voyage, a kite—carrying "a fool or a drunkard"—was sent up for augury. A somewhat inefficient way to see how the wind is blowing.

The idea of a man-carrying kite lay quietly for nearly three centuries. In 1589, in Italy, Giovanni Battista della Porta described a kite—how to make it and how it acted in relation to the flow of air. In the expanded edition of his "Magia naturalis" he concludes: "Hence may an ingenious man take occasion to consider how to make a man fly with huge wings bound to his elbows and knees."

White points out that several Latin editions of della Porta's work were issued in the late 16th and 17th centuries, as well as versions in Dutch and English. Della Porta's passage was quoted verbatim by Johann Jacob Werker (Basel, 1613), and that work reprinted three times in Latin with French and English translations. The principle of so-called "heavier-than-air flight" was, moreover, correctly stated in a work of Samuel Johnson's: "You will be necessarily upborn by the air, if you can renew any impulse upon it, faster than the air can recede from the pressure." This idea was not vindicated, however, until December 17, 1903, at Kitty Hawk.

Despite what looked like an auspicious takeoff, winged flight fell by the wayside. The focus shifted away from what seemed, in retrospect, to be the real problems of aviation to balloons and airships—lighter-than-air devices. The tradition was revived only in the 1880s, by a Californian and a Pomeranian. In fact the latter, Otto Lilienthal, in 1889 declared the balloon to be a blind alley. Two years later he built his first glider, which was to inspire the experiments of the Wright brothers. In 1896 Lilienthal, who was fond of saying "sacrifices must be made," crashed in the Stollner Hills, where he had long been accustomed to experiment with his gliders. He died the next day in a Berlin clinic.

When the Wright brothers came on stage in 1899, practical aviation was at

[3] It has been shown that the human musculature is such that it cannot power birdlike flight. As a reader points out, it has also been shown that the bumblebee can't fly.

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a standstill. Determined to get up in the air and fly, they decided that the best way to gain experience was with a glider flown like a kite. Their first model had no tail—and despite Eilmer's contention that this was what did him in, it flew. Later the tug of the kite string was replaced with motor-driven propellers.

Nothing practical in the way of winged flight was achieved until the development of the internal combustion engine.[4] But it is intriguing to speculate how history might have changed if at the time of Benjamin Franklin kites were *not* a novelty, and the idea of "flapping wings" had been taken less seriously.

Geometries

"I invented number, the most exquisite instrument."

Science fiction fans have long been familiar with the world of the Moebius strip: one-sided, one-edged . . . endless. Such a band with a half-twist was first described by August Ferdinand Moebius, a German mathematician and astronomer, in 1858, ten years before his death. Right? Well, not exactly. A Roman mosaic of the third century pictures two such strips in its border—1,600 years before the advent of modern topology.

The mosaic, which hangs in the Museum of Pagan Art in Arles, France, is apparently nothing much as mosaics go. Strictly utilitarian, it was no doubt a floor covering in a villa of the colonizing Romans. In 46 B.C. Julius Caesar gave Arles to the men of his sixth legion; it became known as "the little Rome of Gaul." The central picture of this mosaic, uncovered by Lorraine L. Larison, shows Orpheus surrounded by a group of animals, apparently spellbound by the notes from his lyre. The border has 16 squares, 12 of which are symmetrically arranged duplicates. All but one pair use commonly found motifs: interwoven strands and coils and lattices.

The final pair illustrates the striking Moebius strip. A model of the band the artist was trying to reproduce can be made with a strip of paper with five half-twists. The two bands in question are located off-center and stand out because they are the only three-dimensional designs in the border. The mosaic-maker knew what he had; the surface is traced in tiles of shades of a single color. No one has ever seen another like it—though a search of Gallic mosaics of that time was made.[5] Since Greek and Roman mosaic-makers wandered throughout the land, pattern-books in hand, it is hard to understand why the Arles mosaic seems to be unique.

The Moebius strip is more or less a curiosity. Passing from its topology, however, to another more specialized kind of geometry leads to a wonderful example of a "born-again" idea: that of *projective geometry*.

It is based on the notion of a straight line. It is not necessary that two figures be congruent in order to be equivalent; one can be the *perspective* of the other.

[4] This, incidentally, can be traced to the invention of the cannon early in the 14th century.

[5] Examples of the symmetry groups so basic to modern-day physics and mathematics also have been found in ancient mosaics.

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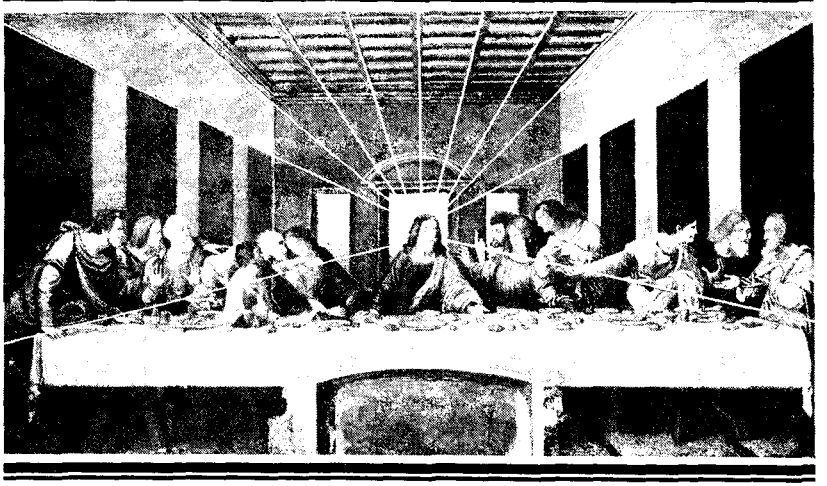
Renaissance painters created this idea to represent three-dimensional realism in two dimensions. An outstanding example is "The Last Supper" by Leonardo da Vinci. The viewer feels he is in the room. Receding lines on the floor, ceiling, and walls imply depth, and all attention is focused on Christ since all lines converge on his head.

To do this Leonardo had first to imagine Christ surrounded by his disciples, then to suppose that rays of light emanated from each point in the scene to a single eye. These converging lines are known as the projection. Next Leonardo had to suppose that his canvas was really a glass screen between the eye and the scene. The points where the lines of the projection intersect the glass screen form a "section." After all this imagining, *all* Leonardo had to do was put on canvas exactly what appeared in the section. (A related problem is that of making a map; that is, projecting figures from a sphere onto a flat sheet of paper. The latter is the section of the projection.)

The importance of projective geom-



Leonardo da Vinci used projective geometry in "The Last Supper." Lines drawn on this print indicate the parallel lines coming out toward the reader, all of which seem to converge at a single vanishing point.

etry today lies not only in the fine art it produced but in its profound impact on physics. Those trying to develop a theory of relativity were interested in pinpointing basic laws of the Universe that are invariant: that is, that do not change in moving from the coordinate system of one observer to that of an-

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In this woodcut by Albrecht Dürer, the artist uses projective geometry to determine perspective. He marks the point at which light from the subject to his eye intersects the glass screen.

other. Projection is a mathematical transformation which ought not change any of the physics of what happens. It simply looks at a given situation from a different point of view. The mathematics which shows this invariance is, to a mathematician or theoretical physicist, breathtakingly beautiful. As Morris Kline has put it, "The science born of art proved to be an art."

The tale begins in the first half of the 17th century with a self-educated architect and engineer, Gérard Desargues. He chose the problem he did "having observed that a good part of the arts is based on geometry, among others, the cutting of stones in architecture, that of sun-dials, that of perspective in particular." His motives in trying to understand and—if possible—synthesize the many theorems on perspective were practical. "I freely confess," he wrote, "that I never had taste for study or research either in physics or geometry except insofar as they could serve as a means for arriving at some sort of knowledge."

Desargues's book laying the foundations of projective geometry appeared in 1639. With the exception of René Descartes, everyone thought the ideas it contained were absurd. The new geometry, unlike that of Euclid, was one with *no* parallel lines. In Euclidean geometry the rails only appear to meet in the distance. In projective geometry par-

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allel lines (in Euclid's sense) meet in a point. It may be infinitely distant, but it is assumed to exist.

Sad to say, all the printed copies of Desargues's book were lost. Only a manuscript copy survived, and even it disappeared from view for 200 years. In the meantime, most of Desargues's discoveries were re-made independently.

Projective geometry was revived in a Russian prison cell. Jean Poncelet was an officer in Napoleon's army during the invasion of Russia. Captured, he spent the year 1813–14 in prison. To keep his sanity, he spent the time mentally reconstructing what he had learned from Gaspard Monge at the École Polytechnique. (Monge had earlier set out to show the richness of geometric methods by applying them to new areas of mathematics. At that time analytic geometry—the combination of algebra and geometry through the method of analysis—reigned supreme.[6] What Monge actually did was create a new geometry, which uses projection and section.)

After his tour de force in reconstructing what he had been taught, Poncelet went on to create new results in projective geometry. In the late 19th and 20th centuries, the theorems of Euclidean and non-Euclidean geometry were deduced from axioms of projective geometry.

[6] Usually attributed to the great 17th-century philosopher René Descartes, the development of analytical geometry in fact goes back over 2,000 years, to attempts to solve the famous riddle of the oracle at Delos.

Black Holes and Antimatter

"There is more matter yet for you to admire in the resource of my imagination."

Two of the most revolutionary ideas of the century are, in fact, not of *this* century. In the late 1700s an English physicist and a long-famous French mathematician independently concocted the bizarre notion of a black hole. Scarcely a century later, in an article in *Nature*, the equally weird idea of antimatter was proposed.

In 1933, long before the identification of the antiparticle of the proton, the antiproton—and therefore long before the reality of antimatter had received any real support—P.A.M. Dirac said in his Nobel lecture:

"If we accept the view of complete symmetry between positive and negative electric charge so far as concerns the fundamental laws of nature, we must regard it rather as an accident that the Earth (and presumably the whole solar system) contains a preponderance of negative electrons and positive protons. It is quite possible that for some of the stars it is the other way about, these stars being built up mainly of positrons and negative protons. In fact, there may be half the stars of each kind. The two kinds of stars would both show exactly the same spectra, and there would be no way of distinguishing them by present astronomical methods."

It is uncanny to pick up an 1898 copy of *Nature* and find Arthur Schuster, a well-respected member of the mathematics faculty at the University of Manchester, speculating that something is wanting in our conception of the

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Universe:

"We know positive and negative electricity, north and south magnetism, and why (do we) not (know of) some extra terrestrial matter related to terrestrial matter as the source is to the sink, gravitating towards its own kind, but driven away from the substances of which the solar system is composed. Worlds may have formed of this stuff, with elements and compounds possessing identical properties with our own, undistinguishable in fact from them until they are brought into each other's vicinity. If there is negative electricity, why not negative gold. . . ."

Later in his letter, entitled "Potential Matter—A Holiday Dream," Schuster uses the words "antiatom" and "antimatter." This letter drew a number of comments. Among them were remarks that two other researchers had earlier—in 1891 and 1897—found implications of the existence of "negative matter."

No one seems to have taken the idea of this fundamental symmetry any further, however, until Dirac. And, in fact, there was a good deal of resistance in 1933 to *his* crazy ideas. Physicists at the time argued that they had the proton, the neutron, and the electron. That was sufficient to build an atom. Surely, the doubters said, we don't *need* any more particles.

But need it or not, the antiproton was discovered in 1956. Since then antiprotons have been tamed; they are now routinely used to study the many elementary particles that exist, and their properties.

But do—as Schuster already hinted and Dirac echoed—large clumps of antimatter exist somewhere in the cosmos? No one can rule out the possibility. Over the years it has been proposed that everything from UFOs to meteorites is really antimatter impinging on our world. Meantime, a natural process has been suggested whereby matter may have come to dominate over antimatter in the early Universe.

To return to the *black hole*, that strange object which opens up limitless possibilities in both fiction and scientific fact. Arguing from the black hole, some physicists now think that the Universe may be unstable. The idea is that a black hole is a bottomless pit. As such it may even, some folk have tongue-in-cheek suggested, be a solution to man's garbage problems. But while matter is sucked in, *both* matter (protons) and antimatter (antiprotons) can leak out. Hence, the number of protons in the Universe is not a constant. If the proton does not live forever, so too may all of matter be mortal.

While the term "black hole" was coined only some 15 years ago, its concept goes back almost 200 years. The English physicist John Mitchell read a paper to the Royal Society of London in 1783. If, he said, Newton is right and light consists of a stream of particles, such particles should be affected by gravity in the same way as are material bodies. Therefore, light moving away from a massive body should be slowed down. In fact, Mitchell argued, light cannot escape from a body having the same density as the Sun but a radius 500 times greater, since the escape velocity at the surface of such a body would be greater than the speed of light.

In 1796 the eminent French mathe-

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matician Pierre Simon Laplace took much the same line in his *Exposition du Système du Monde*. He also suggested that a body with 250 times the radius of the Sun and the same density as the Earth would be invisible because its light could not escape.[7] While Laplace has been criticized for his biased handling of astronomical discoveries in his book, the fact that he understood the black hole idea is clear. The proof of his at first unsubstantiated statement appeared three years later.[8]

But it was not until 1916—just after Einstein's general theory of relativity was published—that the idea of the black hole came around again. This was the work of the German theoretician Karl Schwarzschild, who described space-time in the vicinity of a spherical lump of matter. The black hole—an idea before its time—is now of great interest to astrophysicists. And in the last few years experimental evidence for their existence has been found.

Burning Mirrors and Telescopes

"Struggling improvidently, until I Charted the intricate orbits of the stars."

In 1632 Bonaventura Cavalieri published his "Specchio" in an attempt to resolve an age-old dispute. Could Archimedes really have used mirrors "to burn the enemy fleet a bow-shot off"? No one doubts Archimedes's other exploits in the more usual forms of military engineering, during the siege of the city of Syracuse by the Roman consul Marcellus in 212 B.C. The question Cavalieri concerned himself with was whether Archimedes had had enough information to make such a weapon of war work.[9]

Lenses and mirrors no doubt played some part in fire-making in antiquity, but from a small mirror to a large weapon of war is a large step. In what really turned out to be a work on optics, Cavalieri as a byproduct came up with the idea of the reflecting telescope. (By way of belated introduction, Cavalieri was a man of the cloth and influential in preparing the ground for the integral calculus of Newton and Leibniz.)

Now, the refracting telescope had already been invented by Galileo in 1610. It used lenses to form images, as do modern binoculars and cameras. But shortly after its development its shortcomings became apparent. Of concern was the fact that any enlargement of the image led to a serious loss of definition. The enlarged image, moreover, was surrounded by a ring of colored fringes.

One way of getting around this was to design a different sort of telescope—a mirror, or reflecting, telescope. And in fact Galileo received a letter in 1626 from Bologna in which it was said that

[7] Since the density of the Earth is about four times greater than the density of the Sun, these two suggestions are in quite close agreement.

[8] L.J. Curtis of the University of Toledo found this, and translated it from the Swedish for me. Other readers as well were generous with suggestions, which unfortunately did not fit into the categories chosen.

[9] In a 1977 re-examination of the facts, D.L. Simms, who lives in Great Britain and has worked on fire research, concludes he did not.

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a certain Giovanni had a drawing to show that he could "make a concave mirror which . . . can light a fire everywhere at a time or at a single place as desired . . . (and is) able to make a mirror which by reflection can, and indeed does, produce the effect of the telescope."

In this same letter was mentioned another mirror, that of a Grand Duke, which did the same. Galileo was intrigued and replied with interest. But the drawing could not be found, and the ducal mirror seemed enveloped in secrecy. It had apparently been seen only by a group of men quite ignorant of science, and denied to those who would have understood the principles involved.

Meanwhile, Cavalieri systematically worked out the principal optical properties of reflecting surfaces and summarized his results in a convenient table, the "Tavola Specolaria." He may well have anticipated Newton's 1668 reflecting telescope—which, writes Henry C. King, was "little more than an interesting scientific toy." Clearer and stronger, however, writes Piero E. Ariotti of Verrazano College in New York, is the claim that Cavalieri had the idea for another kind of reflecting telescope, known as the Cassegrainian telescope.[10] Perhaps, speculates Ariotti, this went unnoticed because it appeared in a section on the reflection of sound, in a description of what Cavalieri called "the acoustic vases of Vitruvius."

The Cassegrainian telescope supplements the concave mirror with a convex. It has a number of advantages over the Newtonian telescope, but these were not pointed out for nearly a hundred years. In 1672 Newton was more concerned with putting in his place the upstart Frenchman Cassegrain, said to be a professor at the College of Chartres. He wrote:

"The advantages of this design are none, but the disadvantages so great and unavoidable, that I fear it will never be put in practise with good effect. . . . I could wish, therefore, Mr. Cassegrain had tried his design before he divulged it. But if, for further satisfaction, he please hereafter to try it, I believe the success will inform him, that such projects are of little moment till they be put in practise."

Sir Isaac was not exactly a lovable chap.

To advance Newton's claims of priority, the Royal Society sent a description of the reflecting telescope to Paris to ensure that the French Academy heard of it. In England, Newton was elected Fellow of the Society at the same meeting (January 11, 1672) at which his second reflecting telescope was displayed. On the continent, Newton became known as "the telescope-maker of England." While it was said that far less light was lost by reflection than by refraction, Newton's mirrors in fact reflected only about 16% of the incident light. The problem, as always, was with the mirrors. (Newton's contained too much copper and tarnished too easily.)

[10] Now, in fact, this case history is qualitatively different from our others since *all* major telescope designs seem to have been anticipated.

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To return to Cavalieri. He was in communication with Galileo, but his "Specchio" seems not to have been widely read. Even if it had been, there were inherent difficulties in grinding a reflecting mirror to the shape of a parabola. Some years after he wrote the "Specchio," Cavalieri tried but could not make a parabolic mirror. Also no doubt coming between him and the telescope was his absorbing interest in the problem of Archimedes's burning mirror. Perhaps in 1632, writes Ariotti, "it would simply have been too much for scientists to abruptly turn their backs on that instrument which in less than three decades had so revolutionized and so enlarged their knowledge of the heavens: the refracting telescope."

James Watt and the Chinese Box-Bellows

"Yoked the prancing mounts of opulence,

Obedient to the rein, in chariots."

"If I had a handbook of human history with a chart," writes Eugene S. Ferguson, "one might expect the chart to reduce the industrialization of England in the 18th century to the words 'James Watt,' 'steam engine,' and 'textile mills.' " Ferguson goes on to point out that Watt did not invent the machine that supplied power to the looms of the textile mills. Steam engines, he says, had been put to work fifty years before Watt appeared on the scene, and the industry that created the demand for them was not weaving but mining. Well, Professor Ferguson, things seem to be a bit more complicated than that.

The steam engines of Thomas Newcomen, ironmonger and preacher on occasion, did in fact predate those of Watt. They, like Watt's early engine, were based on what is known as "the single-acting principle" and useful only for pumping. The invention Watt patented in 1782 and again in 1784, and of which he said he was prouder than any other, was "a double-acting machine." That is, steam and vacuum were applied to opposite sides of the piston alternatively.

The double-acting principle was previously known, however, in the form of the Chinese box-bellows. It has been known since the 13th century and may, in fact, go back as far as the 7th.

When one compresses an ordinary Western fireplace bellows, it gives off a blast of air. In contrast, on compression the Chinese box-bellows blows continuously. The central piston is moved back and forth by a handle and is equally active in either pushing or pulling. (Ingeniously enough, chicken feathers form the piston packing in the Chinese version.)

The difference between the box-bellows and Watt's steam engine is that the former is in a sense passive, the latter active. It is like the difference between a scoop wheel acting as a water wheel, and today's turbines, which act as prime movers of water and other fluids.

How else did the ancient Chinese use this idea? Certainly not in the way the idea was re-born to Watt, though in the 11th century they did use it in a military flamethrower for naphtha. The old Chinese flamethrower apparently reveals a good deal about "Greek fire." A "siphon," as depicted in a 10th-cen-

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tury Byzantine manuscript, was fitted to ships of war. From the nozzle a jet of burning liquid was hurled. This grisly weapon enabled the Byzantine Empire to survive the Muslim attacks of 673–678.

The double-acting principle can be used in a machine that is moved *by* a fluid—a steam engine—or in those that *move* fluids—blowers or pumps. The latter use, some historians have long said, first cropped up in the West in 1716 in the design of a water pump.

But Ladislao Reti points out that water pumps based on the same principle had been described by Agostino Ramelli nearly a century earlier. Reti adds that "the extreme complication of Ramelli's machines often makes the recognition of the operating principle difficult." In one instance Ramelli boldly coupled two double-acting curved cylinder pumps. Since they were to alternate, a steady delivery of water would be assured. Reti says this idea was, however, borrowed from Leonardo da Vinci, that great engineer of the Renaissance, and quotes a previous historian, Theodor Beck: "It proves very clearly the dependence of Ramelli on the school of Leonardo." Perhaps.

In any case, Leonardo described continuously sounding musical instruments, among them a portable organ and a bagpipe-like instrument. To keep a man's mouth free (to sing?), Leonardo uses a double-acting bellows, moved by a lever that is connected by a ring with the player's elbow.

In fact, these ideas of Leonardo's are based on another variation of the theme of the box-bellows, the hinged-fan bellows. The oldest illustration of *that* dates to 1313. It is unclear exactly how much older the invention is. Reti says "it bears witness also to one of the earliest attempts to convert rotary motion to reciprocal motion."

In machine design, this principle is second in importance only to the wheel. It is embodied in the common, twice-bent lever called a crank. The Chinese of the Han Dynasty knew about a crank. But the idea was only re-born in the West very much later: in the rotary grindstone (one is pictured in the Utrecht Psalter), in the 10th-century hurdy-gurdy, and finally, around 1504, in Leonardo's musical inventions.

Are we at an end? Reti teases. No, he says, because there exists in the British Museum the manuscript of an anonymous Italian engineer, probably a citizen of Siena. Numbered 34.113, it contains a picture of a double-acting forge bellows[1] that dates to the 1470s.

Why then did widespread application of the double-acting principle have to wait until James Watt? Reti offers a number of possible answers: The size of Western industrial installations and the difficulty of constructing a Chinese-type bellows for the large capacities required. New devices, which made the principle less relevant. One he mentioned—the requirement of the flow of air or water by aid of an air chamber—was described by Vitruvius, but apparently forgotten until the appearance of

[1] It was in this *same* manuscript that there was uncovered the idea of a pre-Leonardian parachute. Ten generations elapsed between the idea and the first jump, made in 1783.

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fire engines in the 17th century. (Fire engines themselves may be a born-again idea, since Ctesibius of Alexandria built something that might be considered such around 200 B.C., but which apparently remained quite unknown in Europe.)

Concentric Spheres

"And I set in order the forms of prophecy . . .
So leading them into the difficult art
Of divination by burnt sacrifice."

Our last case is a particularly intriguing one, illustrating as it does that good ideas can be re-born again as bad ones. And then they never go away.

In 1692 the great astronomer Edmund Halley published a paper in the *Philosophical Transactions of the Royal Society of London*, one of a series in which he presented data on the nature of the magnetic poles. He was hard put to organize the multitude of observational facts into a logical system. What he did therefore was use the idea that the Earth consists of nested spheres. In this way he could explain changes in the position of the magnetic poles. Halley wrote:

"In order to explain the change of the Variations, we have adventured to make the Earth hollow, and to place another Globe within it; and I doubt not but this will find Opposers enough. I know 'twill be objected, That there is no Instance in Nature of the like thing. . . ."

Halley's essay was condensed and apparently widely circulated, but it does not seem to have been well received. In 1716, after a spectacular display of the northern lights visible throughout northern and western Europe, Halley expanded upon his original idea.

The lights, he said, were caused by the Earth's internal spheres. These he supposed to be perpetually lit, and some of the luminous material therein had escaped. This material would naturally escape where the outer sphere was thinnest—in the far north.

The American Puritan Cotton Mather picked up the idea and used it in 1721 in *The Christian Philosopher*, one of his more than 450 books. In Chapter 24, "Of Magnetism," he clearly describes Halley's notion of concentric spheres. And nearly 100 years later, the notion came around again. Independently? No one is quite certain. But it certainly was bizarrely.

John Cleves Symmes suggested that the Earth was hollow, habitable within and widely open about the poles. Nephew of a continental congressman by the same name, Symmes was born in 1780 and died in 1829. Two years after he retired from his captaincy in the military service, he announced his *discovery* in a circular. It is said this 1818 circular went to nearly every learned institution in the U.S. and Europe. A book detailing it and compiled from his writings was published by his son Americus in 1878.[12]

And so an idea that started out as a true scientific conjecture turned into the fictional notion of a subterranean country. It would seem, writes Conway Zirkle, that a knowledge of the sphericity

[12] A book lampooning it, *Symzonia, a Voyage of Discovery*, was written by one Captain Adam Seaborn. Some say this was Symmes himself.

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of the Earth, combined with a belief in an underworld, would lead logically to a view that the world is composed of concentric spheres. In any case, it has often been re-born, in many places: the potboilers of Edgar Rice Burroughs. Jules Verne's *Voyage au Centre de la Terre*. Bulwer-Lytton's escapist utopia in *The Coming Race*. At least two other "concave" cosmogonies were developed, one in 1870, another in 1913. And last but by no means least, modern geological models divide the Earth into several concentric spheres.

In Conclusion

"Formed the alphabet, the tool
Of history and chronicle of their progress."

How does it happen that ideas are born, lost, and come around again? No one *really* knows, but one can speculate a bit. It all has to do with the resistance of scientists to new ideas. Older scientists resist those of younger; Westerners those of Easterners (and vice versa). Specialists resist those of non-specialists; technologists those of "pure" scientists. Some scientists are anti-theoretical, believing only in ideas based on the direct evidence of the senses. Others question the use of mathematics. Still others laud it. Some reject that for which they have no immediate use. There is a certain arrogance about the scientist.

Not so long ago, I was seriously assured by a well-known plasma physicist that "physics has no history." A silly statement. But such an attitude has a good deal to do with how (or if) ideas are spread. It crops up in various ways, not necessarily malicious. Recently Caltech's Richard Feynman, who has been billed by *Omni* magazine as "the smartest man in the world," was lecturing on the topic of how small one can make a computer. At one point he quite charmingly confessed that he was sure others had explored such and such a question, but that he had not bothered to find out; it was easier for him simply to re-invent what he needed.

Who knows what ideas are thus passed over? It is rare in the history of science to find scientists more excited about what can be learned from their predecessors than so-called "new"—and hence by definition "original"—ideas.[13] It is more likely that the scientist becomes gladiator, rushing off to do battle for the priority of his thinking.

. . . Recall Sir Isaac and the reflecting telescope.

. . . Or think of Galileo protecting his "right" to the refracting telescope by flaying one Grassi, who "tried to diminish whatever praise there may be in this (invention) which belongs to me." Galileo talked as well of others who "attempted to rob me of that glory which was mine, pretending not to have seen my writings and trying to represent themselves as the original discoverer of these marvels."

. . . Or consider the more recent example of Cincinnati's Alexander B. Latta, hailed as the inventor and builder

[13] A striking exception is the Italian Tartaglia, who to solve the perennial task of salvage in 16th-century Venice turned back to the *Hydrostatics* of Archimedes. He was the first to translate that work into a living tongue.

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of the "world's first steam fire engine." There were others long before him, but he came to get top billing by declaring, as early as 1857, "I am the only man that has built a successful machine in this country or anywhere else."

No one questions that a scientist should have the joy of discovery and the glory of it. But arrogance can get in the way of science. A classic example is the tragic case of the midwife toad.

At the turn of the century, Mendel's theory of inheritance had been, after 35 years, rediscovered in Germany, Holland, and Austria. It said that only those characteristics already present in the genes could be inherited. The genetic theory became scientific orthodoxy.

Soon, however, the Austrian biologist Paul Kammerer announced that he had persuaded midwife toads to breed in water, and that as a result of this they had re-evolved nuptial pads. (Ordinarily male toads grow "pads" on their hands to help them hold onto the female's slippery back while mating in water. The midwife toad was said to have lost these pads as a consequence of mating on land.)

The Mendelians hounded Kammerer to death by suicide, charging even that the black pads had been manufactured by injecting India ink under the skin. What was truly at issue was that his experiments were thought to support the rival Lamarckian theory, which asserted

[14] The clue emerged only later. Kammerer had weeded out eggs that "were unlikely to survive"; the few remaining eggs apparently had genes pertinent to an earlier aquatic way of life.

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that acquired characteristics could be inherited. In fact, it later turned out, Kammerer's extraordinary results were dramatic evidence *in favor* of the Mendelians' theory.[14] Sad to tell, a report of a wild midwife toad with such pads existed in the literature at the time. It just didn't surface in the fray.

This brings us to the notion of obscurity—which seems, in fact, only to be a pseudonym for "non-recognition." Historians are fond of lamenting the shame of Darwin's not being aware of Mendel's work. Darwin was searching for the laws governing inheritance in the *same* year Mendel was announcing them—and without them, Darwin did not have the operative basis for his theory of natural selection.

The little-known monk's great synthesis of data from the bees and the peas[15] was published in the *Proceedings of the Natural History Society of Brunn* (in what is now Czechoslovakia). An obscure journal? Not at all. In 1865 the Brunn society was exchanging publications with 115 institutions and societies, including the Royal Society of London. A pencilled note on Mendel's original manuscript says there were 40 reprints. Four have since been located. The pages were still uncut, on one. Another turned up in the collection of a German zoologist. The third eventually was sent to one of Mendel's re-discoverers. (When *he* read it is unclear.) The fourth was indeed read by a famous biologist of the time: he, however, looked down on the unimportant monk from Brunn. The significance of the work so eluded him that he persuaded Mendel to change course from peas to the hawkweed, and Mendel labored in this blind alley until the end of his life.

There were as well at least four indirect sources of information on Mendel and his work. One was definitely in Darwin's hands, but he seems either not to have read it or not to have grasped the synopsis of Mendel's paper and gone thence to the original source. Peter J. Vorzimmer concludes: "That recognition and appreciation of his discoveries was delayed for thirty-five years was not so much a problem of promulgation within the scientific community as it was an incapacity for members of that community to comprehend what [Mendel] was saying, because of the novelty of the method and the presentation which he had employed." That is to say, he used mathematics to explain biology at a time when mathematics was not a popular tool of biologists. Mendel's difficult mathematical deductions were what would be regarded today as rather simple statistics.

If one wants to be pessimistic, listen then to Max Planck:

"A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."

What may truly be operative—at least on some level—is the fact that it is very hard for a person to deal with the seemingly inexhaustible details of the Uni-

[15] The real problem, says Conway Zirkle, is not to explain why Mendel's work was ignored by his contemporaries, but to explain how it ever came into being.

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verse. The neurons in the human brain are finite, as are the circuits in a computer. There may be just so much storage space available. Hence the ideas that are *one's own*, one hugs very tightly. As long as there are humans, there will be born-again ideas. ■

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● I find the great thing in this world is not so much where we stand, as in what direction we are moving.

Oliver Wendell Holmes

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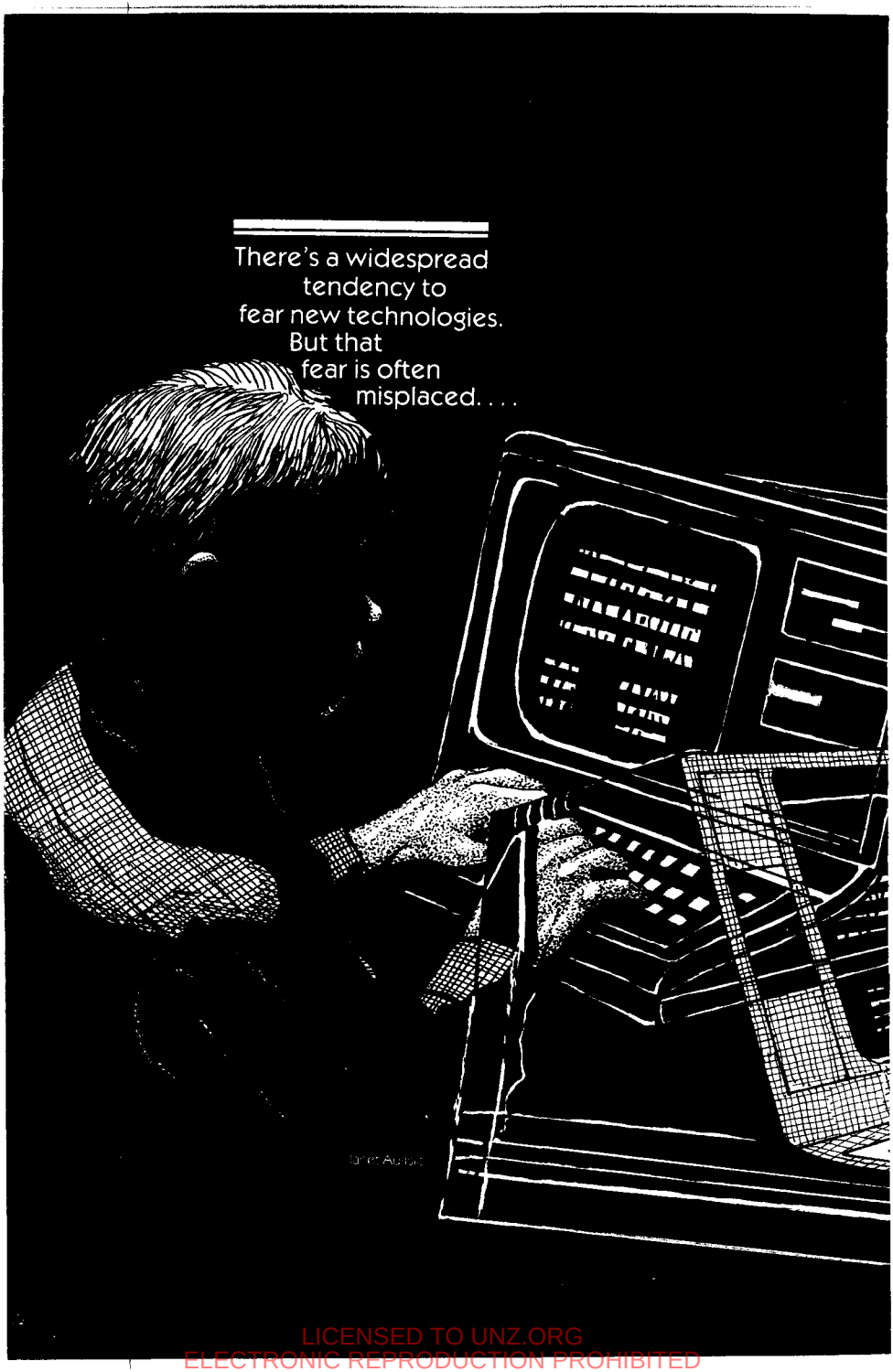

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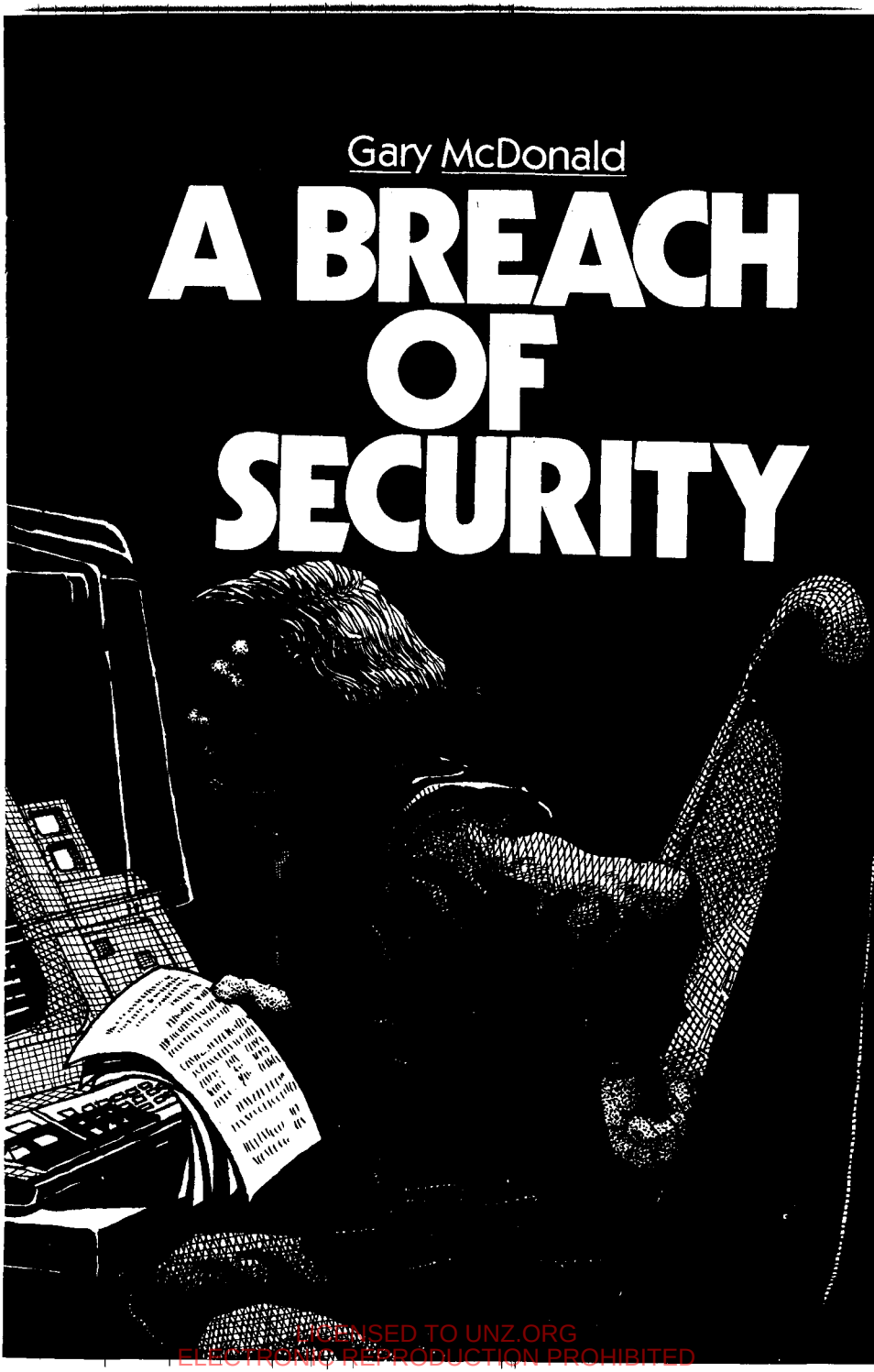
A BREACH OF SECURITY



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Don Young turned from the terminal as the office door opened. "Hello, Felipe!" he said with pleased surprise; but the enthusiasm of his greeting faltered as he saw the grimness in Felipe's expression. "Trouble?" he asked.

"First things first." After closing the door, Felipe took an envelope from his shirt pocket and gave it to Young. "Here's your payment." Felipe's English gave almost no indication of his Mexican origin, except for a slight unevenness of stress that indicated he was not a native speaker. He was taller and, names notwithstanding, younger than Don.

Young briefly examined the bills in the envelope without counting them, then put them into the back of his desk drawer. "Thanks. That's one transaction that won't be recorded in the NIB. But what's the bad news?"

Felipe sat close to Young—he could hardly have done otherwise in that office—and spoke softly, as if from habit. "Carlos Ribera was arrested Tuesday. He's going to be deported."

"What? But his visa was good. I didn't even have to change that!"

"The immigration authorities said it had expired. Yes, he had a letter," he continued quickly, anticipating Young's next question. "But they only care about what's in the computer. We could have tried fighting it, but I didn't think it was a good idea to get the authorities too interested in checking those records."

"I see your point. If they discovered any hanky-panky there, it would be as bad for Carlos as it would be for us. I hate the thought that we're sacrificing him 'for the good of the cause,' but what else can we do?"

"What else can we do? or can you do? I hope you can stop this from happening again." Felipe looked quite agitated.

"I wish I could, but I don't even know how it happened. Somebody could have broken the NIB security the way I did. But who'd go to that much effort to hurt your friends?"

"I don't know." Felipe gestured despairingly at the terminal. "Is it possible you made a mistake when you changed Carlos' record? Perhaps you accidentally changed his expiration date?"

"No! It takes me hours and hours to get access to a record. After waiting that long, I make sure my changes are right."

"I suppose all we can do is hope that this won't happen again. Carlos is a good friend, and Mexico is a very unpleasant place to return to right now. The revolutionaries are getting worse than the government. Did you hear about the latest killings in Puebla?"

"I'm afraid I haven't been keeping up on the news very well lately, in spite of those." He gestured ironically at the pile of unread newspapers that was growing near his feet. "Anyway, I'll run some checks to make sure nothing else like that is going on. Let's just keep an eye on things rather than panicking."

"Good enough," said Felipe. "Or at least, the best we have now. I'll call you tomorrow to find out if you've learned anything."

"Fine. And I'd like to hear from you at once if anyone whose records I've fixed gets into trouble."

"Certainly. Thank you again for

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helping us all." He shook Young's hand and left, still not looking happy.

Left alone, Young had to admit that Felipe had plenty of reason to worry. Young thought he was the only person illegally altering records in the National Information Bank, but now he wondered. Someone had intentionally changed Carlos' record. An NIB official would be able to take direct action; more probably it was some user of the system who had broken its security and was striking at people with some purpose of his own. In that case, it was likely that nothing more would come of the chance encounter.

Young hoped this was so; but to satisfy his doubts, he set up a program to check on the three people whose records he had changed that week. Getting at them a second time would be quick.

Within twenty minutes he was examining the slightly cryptic contents of the first record. Its visa expiration date was unchanged, but the priority rating for Juan Schiller was down to "2" —worse than before, and virtually unemployable.

The other records, for Pedro Domingos and Maria Martinez, were unchanged. But two such incidents had to be more than coincidence. Someone was dogging his changes to the records and was counterattacking with modifications that left the affected people worse off than before.

The immediate damage could be undone, at least. Young changed Schiller's priority rating back to the 16 he had given him on Tuesday. But he knew he was faced with a situation that would not go away—no, "faced" was the wrong word. His adversary was faceless, an unknown person somewhere on the vast network of terminals that had access to the NIB.

Eventually Young admitted to himself that there was nothing more he could do till the next day, so he took the train back to his apartment. After eating a plastic-bag dinner, he slipped a recording of Beethoven's *Pastoral* symphony into his compact-disk player. The quiet opening of the strings put him into a more reflective mood.

How had he gotten into this mess? He had had a perfectly satisfactory job before, and a satisfactory life. But then the NIB had come. Its creation had been a *tour de force* for Senator Martin, who had won the support of liberals and conservatives alike in his campaign for an all-encompassing network of computers that would monitor the economic activity of the United States.

"Vital information is scattered all over hundreds of incompatible computer systems," Martin had declared. "It's redundant, it's inefficient, it's costing the taxpayers millions in lost time and lost data. It lets unscrupulous people rob the public blind. What we need is a National Information Bank that will hold everything the government needs to know."

Senator Martin had shown amazing skill in persuading people across the political spectrum. Many who weren't convinced by his argments for efficiency were attracted by his promise that the system would keep better track of foreigners who were depriving Americans of jobs. He had known when to make strategic concessions to appease the system's opponents. When he gave

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his support to provisions that would guarantee the public direct access to all data in the system except for specific information on individuals, enough of the opposition died down so that the bill squeaked through to the desk of a sympathetic President.

Young hadn't been able to understand why people accepted it. Perhaps it hadn't seemed real to them until they saw the terminals installed in every store larger than a corner grocery shop, until they had to give their Social Security number every time they made a purchase of over two hundred dollars. But by the time the system came on line, the opposition lost its momentum, and the reality of the system did not produce enough of an outcry to get Congress to reconsider.

Out of Young's explosion of anger when the NIB went on line came the realization that he could do something. During his student years and since, he had made himself an expert at penetrating computer systems for the fun of it; he now had a use for this expertise.

It was a simple enough matter to set himself up as a consultant helping people to get information from the NIB. Simple—except for the personal cost of losing his fiancee. "I don't understand," Gloria had cried out. "Why do you want to leave a job that you like, one that pays you well, and start a shoestring business that can't go anywhere?" He didn't dare explain to her.

His initial hope was to find some flaw in the system that would let him stop its operation. But his best efforts, including getting a machine-language dump of the NIB's operating system, left him with nothing more definite than the feeling that it could have been designed better.

In probing the system, though, he found that the allegedly unbreakable security of its records had some fatal weaknesses. There was a way to translate Social Security numbers into access keys. Not an efficient way, to be sure—it generated a set of possible translations, each of which had to be tried in turn—but a way that let him get at any record for which he had the Social Security number. It was something, if not much.

After that, he had to make contacts without revealing his intentions to the wrong people. Felipe's group was a lucky find that gave him a lot of encouragement. "It only seems hopeless," Felipe once said in an optimistic moment. "The right spark could turn people against this computer bureaucracy."

Today, though, it seemed more hopeless than it ever had before. The calm rippling of the brook which the music was recreating made Young's thoughts seem all the more violent; he restrained a desire to jerk the disk out of the player and give himself some quiet without peace. But his mind gradually cleared. Perhaps it was possible, after all, to find out who was doing these things. If only he knew who his adversary was, then he could fight.

How would he fight? He admitted he didn't know, but that could come later.

By the next morning he had formulated a strategy. He could set up a program that would watch for changes on certain records and take a "snapshot" of system usage at the time the change occurred. It might take days or weeks

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before a pattern emerged, though, and time was against him. His adversary could quit the game at any time, waiting for Young to make the next move. But it was the best he could do.

The program, which he wrote in the Common programming language, took him only a couple of hours to prepare and debug. After that he checked whether the last records which he had altered the day before had been attacked again. They hadn't; apparently the unknown enemy wasn't an early riser. He set the program running and left the office.

When he came back at one in the afternoon, his eyes immediately went to the screen. To his satisfaction, it displayed the message "Someone's been here" not once, but twice. He entered a command to display the file his program had created.

The changes had occurred shortly before noon, eight minutes apart, and it wasn't surprising that almost exactly the same list of a hundred-odd users was present both times. While the differences would be useful, it would take many such lists to narrow it down to one suspect, Young thought—

—When his eyes were caught by a name that occurred in both lists. The name was "Mitchell." It's a common name, he thought; it's probably someone else. But his fingers were cold as he typed in the command "who is Mitchell." The response came back quickly:

OSWALD MITCHELL—NIB CONSULTANT

He no longer had any doubts about who his adversary was. Young had never met Os Mitchell, yet they were well acquainted with each other. He had known Mitchell by reputation from his days at the University of California at Oakland. Mitchell, who had graduated just before Young entered, had been known there as "the Wonderful Lizard Os," the greatest computer hacker of his time. He had "met" Mitchell in one of the interest groups on the Homenet information system, and for nearly a year they had exchanged messages regularly.

They had loved to talk politics and often seemed to agree, but Young knew there was a difference that sundered them at the root. For Mitchell, the foundation of civilization was the law. He had expressed his dislike for many particular laws, but he had maintained that everyone had a moral obligation to obey a bad law until it could be changed.

Young, on the other hand, held that a law was just the expression of some people's desire to compel other people to act in certain ways, and that no law had any effect on what was right or wrong. He was sure that Mitchell, in spite of his enjoyment of harmless hacking, would not approve of anyone's tampering with NIB records.

It seemed very strange that Mitchell would go to the trouble of striking back this way, but there was no question of his ability to do it. If there was anyone in the country who could outclass Young at computer hacking, it was the Lizard. And if he was attached to the NIB, then he had more resources at his disposal than Young did. How was he supposed to win a battle like this?

Still, he did have one advantage. Mitchell did not know (he hoped) that Young knew about his activities. That might allow him to grab the initiative.

* * *

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At half past four, Don Young was riding the train back from Oakland with a very useful sheet of paper in his pocket. It had been a delicate matter to get Mitchell's transcript along with his own, but he had come up with enough information about the courses Mitchell had taken to persuade the clerk that he really was just picking it up for a friend who couldn't make it.

But he now had an important piece of information—Mitchell's Social Security number, which had been used as a student identification number in those days of less caution. It would give him power over Mitchell, the kind of power that had once been thought to belong to someone who knew another's true name.

He pondered his next action as the train bounced him along. He could plant evidence of tax evasion on Mitchell, or embarrass him with bad credit, or something like that. But those things would take time to have their effect, and they wouldn't stop him from continuing to play with the Mexicans' records. Besides, he had come to think of Mitchell as a friend, in spite of their disagreements. He really didn't want to hit him with a sneak attack.

But perhaps there was another way.

After returning to the office, Young checked and found that Mitchell was still on the system. Then he typed "call Mitchell," invoking the system's interterminal conversation facility.

He waited for Mitchell to notice the call and get ready to reply. It was no more than the delay of waiting for someone to answer a telephone call, but there wasn't even the sound of ringing to give him the feeling that something was happening somewhere.

At last the terminal responded, "Connection established."

Hesitantly, Young typed, "I'd like to talk to you."

A short delay, and then the terminal answered, "I thought you might be calling, Don."

"I think we should go by Cryptex for this," Young typed.

"Okay. I'm changing over now." The Cryptex scrambler had become a popular accessory to terminals in the last few years. Young and Mitchell had used their Cryptexes before to discuss confidential matters across Homenet, using an encryption keyword which they had agreed on months ago.

He set up his unit, and after a little while a line appeared: "Are you still reading me?"

"Loud and clear," Young typed. "Now just what are you up to with these Mexicans?"

After a rather long pause, the terminal responded, "You probably know I was working on the development of the NIB. I know what you think of it. I'm not totally thrilled with it either, especially things like setting employment priorities. But I'm much less thrilled with what you're doing with it.

"I wasn't involved myself in the security system. If I had been, you wouldn't have been able to break it (pardon me for bragging). But I did notice after it was done that it wasn't done very well. I'd demonstrated how I could break in, but the people in charge weren't impressed by an insider doing that. So all I could do was keep an eye out for anyone who might try to break into the records. When someone did, I'd report him and prove my point. But I hadn't figured

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that you'd be the one to do it. Probably I should have."

"So you decided not to turn me in," Young typed, "but to use my own methods against me?"

"That's a reasonable way to put it. The more you try this sort of thing, the more I'll mess your efforts up. From what I've seen, your programs aren't as efficient at cracking the passwords as mine. So I can stop you faster than you can make a move."

"What do you have against these people?" Young typed angrily.

"I don't have anything against them," Mitchell responded on the terminal's screen. "But you're breaking the law to give them an advantage that society hasn't chosen to grant them. That's a very dangerous precedent."

By now Young was used to "talking" with Mitchell in this way, but it was still frustrating at times like this. He had the words, but not the inflections of voice that normally added so much to the meaning of a statement. There was nothing but glowing green letters, adding to the impersonality of a discussion that was headed toward the abstract in any case.

He knew from their previous discussions that his best arguments would only lead to an impasse. But then a different sort of thought occurred to him: if he couldn't convince Mitchell to desist, perhaps he could get him to convince himself.

"People have certain rights, regardless of what society may want," he typed, unable to completely shake his urge to argue. "But we've gone through this before, and there's no reason just now for me to convince you of anything. The question you have to consider first is, what right do you have to do what you're doing to me?

"I'm breaking the law, I grant that. Still, what does that entitle you to do, by your own standards? You can report me, if you think that's what's right. Or you can leave me alone. But what business do you have taking the law into your own hands to fight me? No, I'm not being hypocritical. I'm asking you to judge your actions against your own conscience, not mine. If you disapprove of illegal means of achieving justice, you should start with yourself."

Young wondered briefly whether he might have gone too far. Perhaps he would only end up persuading Mitchell to turn him over to the forces of law and order.

"I could have turned you in to the FBI," came the response, "but I didn't want to. Do you have an alternative in mind?"

"One alternative is a truce," Young typed.

"What sort of truce?"

"I'll limit myself to exactly what I'm doing now. That is, I'll change people's records only to take away special penalties the government has imposed on them because of accidents of birth."

"Is that a concession? That's all you were going to do anyway, wasn't it?"

"Not exactly. You decided against turning me in. I also decided against doing something nasty to you without your knowing it. You see, I know your SS number." He typed it in so that Mitchell would know he did.

It was frustrating to drop a bombshell on Mitchell and not be able to see his reaction. Yet he could see it in the sec-

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onds that slowly passed before a response appeared. At last it came: "Is that a threat?"

"If it is, it's lost a lot of its effectiveness by my warning you. I'm not saying I won't ever use it, but I don't want to. We could inflict a lot of harm on each other if it came to that. I'm sure, for instance, that you'd have no trouble getting my SS number and wrecking my records.

"What I'm proposing is that we keep this channel of communication open, either here or on Homenet. I'll listen to any reason you can give for me to stop, if you'll listen to my reasons why I think we should pool our talents to destroy the whole damn NIB if we can. I don't think it's very likely that either of us will convince the other, but I have to grant the possibility. Is that satisfactory?"

This time the pause was over half a minute. Young hoped that he had achieved the right balance. Arguments alone wouldn't have been enough; on the other hand, threats alone would just have spurred Mitchell to proud defiance. "All right," came the response at last, somewhat to Young's surprise. 'I'll desist for the moment. But I want your word on one thing: that you'll tell me about whatever you decide to do to the NIB. In return, I'll give you my word not to turn you in, and not to interfere."

"Why do you want that from me?"

"You can't expect me to give you a promise to stand by, no matter what you do. This way, if you tell me you're going to do something I can't endure—or if you break the truce by trying it without telling me—I can decide what to do at that point."

It was Young's turn to consider now. He was confident from past experience that the Lizard would stick by an agreement once he had made it, but it might limit his own options in the future.

On the balance, he had to admit that having Mitchell for an antagonist was the worse evil. Shaking off his doubts, he typed at the keyboard with the firmness of a handshake: "Done."

That evening, he called Felipe at home to give him the good news. His explanation was brief and left Felipe puzzled, but it wasn't easy to explain why he felt sure that his antagonist would desist.

He wondered himself how long the truce would last. Nonetheless, the first few days of the next week went smoothly enough. His latest changes really did stay in effect, and he added one more of Felipe's friends to his collection of favorably altered records.

On Wednesday, he called up Homenet and found a message from Mitchell waiting for him. After decrypting it, he found that Mitchell had been doubly careful: it was worded as a message from one character to another in a role-playing adventure game, though its real object of dissuading him was plain enough. One part of it stuck in his mind—but not for the reason Mitchell had intended.

"I fear," the message said, "that you might grow even more rash and attempt to destroy the wizard's keep. Consider that in doing so, you might unleash other and worse evils. Consider the consequences to those who dwell in the

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wizard's realm. And in the last event, remember you have given your word to warn me before you attempt it."

Translated, that meant that Mitchell didn't want him to try to attack the whole NIB. But why would he have even raised the point unless there was some way to attack it? The more he thought back on that message, the more Young grew convinced that there was a way to do something irritating and inconvenient, at the very least, to the system. He had virtually given up his scouring through the listings as a hopeless cause. Now, though, he felt that it would be worth his spending more time on it.

He spent most of the week going through voluminous undocumented lists of instructions that described the workings of the system. All he found were a few minor defects, nothing that would give him the lever he needed.

He gave it up for the weekened and devoted his time to the more relaxing business of visiting with friends and bicycling over some of his favorite hills. After a pleasantly exhausting ride, he had no trouble getting to sleep Sunday night.

But at some unknown hour of the night, a portion of his mind remained awake and formed an insistent thought. With an effort, Young roused himself from sleep and opened his eyes in the dark.

He tried to remember what he had been thinking. Yes—there was a logical error in the process creation code which he had been examining Friday. He could see it clearly now in the darkness, and he could see some of its consequences which he had missed completely before.

When the beeping alarm awakened him, it took him a moment to recall the thought, but then it was surprisingly clear. He got up more quickly than usual, anxious to check whether there really was a loophole.

An hour and a half later he was flipping through obscure listings of system code. There it was! He mentally traced through what it would do if he gave it a zero parameter here, and a negative number there. . . .

Yes! It would work! He grabbed a piece of paper and sketched out the program. It was amazingly simple; less than a page of code would be enough to bring thirty supercomputers to their figurative knees.

His elation dimmed for a moment as he remembered his promise. But then he realized it didn't matter. He could tell Mitchell what he was going to do; Mitchell would have no time to react. He laughed quietly at the thought.

While waiting for a reasonable time of the morning to contact Mitchell, he called Felipe and invited him to the office to see "an interesting new development."

He spent the next hour catching up on the legitimate statistical work for the *Chronicle* which he had been neglecting. When Felipe arrived, he said, "I'm glad you could make it for this. I just have to get one thing out of the way first."

Young made sure that Mitchell had logged on. He typed in a request to call him, and the response came rather quickly.

"I don't think we need a Cryptex this time," he typed. "Am I making myself clear enough if I say that I've figured

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out how to breed rabbits, and that I'm about to cancel our previous agreement and prepare a special gift for the wizard?"

"I understand," came the prompt response. "Thanks for telling me."

"Over and out," Young typed. Now he was worried; Mitchell apparently wasn't even surprised. Well, there was nothing to do but go ahead.

He explained to Felipe what he was about to do. "Good!" was all Felipe said as he sat down to get a vantage point on the terminal. Young hit the keys with excessive firmness as he started to type in the program.

Five minutes later he said to Felipe, "I'm compiling the program now. This Common compiler is one of the slowest things ever written." Finally the wait came to an end, and a message appeared on the screen.

"Oh, shit," he moaned.

"What is it?" Felipe asked.

"I can't do what I want to do. Not in Common, anyway. The compiler's too clever about checking for errors. I'll have to do it in assembly language." He pronounced the last two words like a curse.

"Is that bad?"

"Not horrible, but definitely tedious. I haven't done it for years, and never on these machines. Oh, well, it's just a matter of figuring out all the little details. You'll have to excuse me for a while." He took a pad out of his desk and started writing, wondering silently if he was giving Mitchell time to do something to him. Felipe looked on, pacing restlessly in the small office from time to time.

After twenty minutes, he showed three pages of handwritten code to Felipe and said, "This just might work." He typed it in and entered some commands. The result came back in less than a minute—"Errors detected: 27."

"This isn't going well," he muttered, not returning Felipe's glance as he rummaged through his bookcase for a manual.

"Are you sure you'll get this done soon?" Felipe asked.

"I have to! I . . ." He stopped, not wanting to let Felipe know why he had to.

Felipe shrugged and turned his attention to sifting through the pile of newspapers. "Let me know if something interesting happens," he said.

It was almost an hour later when Young made his eighth round of changes to the program, which he hoped would eliminate the last two errors. He typed the assembly command in and declared, "This time for sure!"

The office door opened.

Young turned around, startled. The man at the door was a stranger, about forty years old, with a neatly trimmed beard and a business suit. He was breathing rapidly and perspiring as he looked uncertainly between Young and Felipe.

"No! It can't be you!" Young said against certainty that it was.

"Who else would it be?" the man asked, attempting a smile between gasps. "You haven't done it yet, have you, Don?"

"Do you know this man?" Felipe asked apprehensively.

"I've never met him before—but yes, I know him." Young answered. Turning to Mitchell, he said, "I had to do the silly thing in assembler." He chuc-

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kled to think that his first spoken words to Mitchell, in spite of their battle, would be a confidence about a computer program.

"Assembler?" Mitchell returned the smile. "How disgusting. But maybe it'll give me a chance to talk you out of what you're going to do." He moved tentatively toward the chair which Felipe had just vacated; Young nodded and he collapsed into it.

"You must have come in a hurry." He looked at him with an unspoken question; he had no idea where Mitchell lived.

"All the way from Oakland." Mitchell was gradually regaining control of his breath. "Yes, I'm still hanging around there. But do I understand correctly what you're planning to do?"

Felipe stood and stared at them both, not understanding.

"Just the old idea of the rabbit program. A process that will reproduce itself indefinitely, using up all the system resources. And on a multi-computer system like this, the only way to stop it is to bring all the processors down at once, or the surviving copies will start breeding."

"That won't stop the system for more than a day. And next time they'll be watching to see who runs any funny programs."

Felipe moved closer to both Mitchell and the terminal; Young nodded but motioned to him to stay calm.

"No, it won't kill it. But it'll bring it down for hours. And the embarrassment to the system will give its opponents enough ammunition that they just might be able to get it abolished. Remember how Three Mile Island set nuclear power back for years?"

"I see." Mitchell said, now sounding more or less recovered from his exertion. "Yes, I suppose the effect will be nasty. But there's a much more basic point. The Mexicans"—he glanced nervously at Felipe—"also didn't like the things their government was doing to them. They've ended up in chaos. Certain people would see this as an inspiration to let their own lunacy loose."

"But there's a difference between this and terrorism," Young protested.

"I know that. But the method you're choosing makes you part of the underground." There was a desperate sincerity in Mitchell's voice, an element which had never come across in their faceless computer dialogues. "You won't be able to explain to anybody what the difference is, why you did what you did. Whose mind can you change that way? All you'll have accomplished is causing some inconveniences to the government. That isn't the way to get things changed.

"At least the government lets you know what it's going to do and acts on definite rules. You're not even giving it that in return."

Young began to feel some doubt about what he was doing. It would, he had to admit, be nothing more than an elaborate act of vandalism. It wouldn't prove a point; it wouldn't gain anything in the battle of ideas. On the other hand, it would stop the immediate evil.

He began to wonder whether he was sure enough of the rightness of his course to be willing to put his fate into Mitchell's hands. But his train of thought

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was abruptly interrupted by a loud "Hah!" from Felipe.

"Excuse me?" Mitchell asked as gently as he could.

"The government acts on definite rules?" Felipe retorted. "Sure, if you mean the rule that it can do whatever it wants."

"There are Constitutional limits on what it can do, you know," Mitchell said, sliding his chair away from Felipe.

"Constitutional limits?" Felipe echoed sarcastically as he picked up a newspaper that he had just cast aside. "Do you call this Constitutional limits?"

"What is that?" Young asked, puzzled.

Felipe looked utterly frustrated. "You really don't ever read these newspapers, do you?" He slapped the paper down on the desk and indicated a place halfway down a column of text. Mitchell bent over it, and he and Young read it together.

"In another decision," the article read from where Felipe had indicated, "the Supreme Court ruled that the National Information Bank Administration has full power to subpoena documents of any kind, without obligation to demonstrate a need for the specific information contained therein.

"The majority opinion in the 6-3 ruling stated that 'the needs of the NIB are so broad and varied that requiring it to demonstrate a particular need for any given document would constitute an unacceptable burden. Any issues of due process that may be raised are secondary to the paramount national objective of keeping complete and accurate information.' "

Young closed his eyes in disgust. As he tried to slow his heartbeat, he heard Mitchell whisper a strained "No."

Looking at Mitchell's face, he saw the anger of a victim of a horrible betrayal. "They didn't even find that worth a headline?" Mitchell sputtered. Suddenly he broke off and scanned the entire front page carefully. "It really is the *Chronicle*," he said at last. "Sorry, Don. I just found this so unbelievable that I wondered if you had planted it."

"It's real," Felipe said quietly.

"I give up," Mitchell said. "There isn't any reason for me to fight you now. This country's now in a civil war, just like Mexico. The only difference is that people haven't noticed yet." He got up. "Go ahead. Destroy it if you want. I won't do anything to you."

"Wait!" Young called as Mitchell started for the door. "If you think the NIB's become a lawless monster, why not help me crash it?"

"Sorry," Mitchell said as he paused at the door. "There was once something great about this government of the United States. Even the way it is now, I don't want to raise my hand against it. Besides," he added almost in a whisper, "it's *my* monster." His shoulders slumped, he went out and closed the door.

"What did he mean, saying it was his monster?" Felipe asked.

"He helped to create the NIB."

For a moment Felipe looked as if he wanted to go after Mitchell and strangle him, but the look subsided. "Well," he said as he sat down in the chair, "shall we get on with it?"

"Sure," Young said, sounding somewhat distracted. He turned back to the terminal and saw that the last as-

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sembly had finished without errors. The remaining steps proceeded without a hitch.

The terminal stood awaiting further input, but Young appeared to be lost in thought. "Well?" Felipe asked.

Young shrugged and said, "Here goes," as he typed in the final command.

In hundreds of places around the country, clerks became puzzled as the NIB terminals in their stores failed to register sales. In the NIB computer center, operators grew tense as the familiar sound of printers slowed down and stopped. In New York, a news editor heard that payroll reports to the NIB had stopped going through and began to think of what kind of story might be behind this.

In San Francisco, Don Young and Felipe sat looking at a terminal which no longer responded to the commands Young typed. They were both smiling, but Felipe's smile was one of unrestrained triumph, while Young's showed a certain amount of doubt.

"We've won a battle—but are we fighting the right war?" Young asked.

"The right war? Just what do you mean?"

"Only what our guest was just saying. What we should really be fighting isn't a computer system, but the way of thinking that made it possible. Otherwise it'll just come back in another form. Now we have to stay inconspicuous, when otherwise we might have jumped into the public battle."

"But what you've done will encourage other people to jump into it," Felipe said, giving Young an encouraging pat on the shoulder. "We aren't alone, you know."

"I hope so," said Young. Then, managing more of a smile, he added, "It was worth it anyway. If people understand, so much the better." ■

● Any naturalist who is lucky enough to travel at certain moments has experienced a feeling of overwhelming exultation at the beauty and complexity of life, and a feeling of depression that there is so much to see, to observe, to learn, that one lifetime is an unfairly short span to be allotted for such a paradise of enigmas as the world is. . . . But there is one experience, perhaps above all others, that a naturalist should try to have before he dies and that is the astonishing and humbling experience of exploring a tropical reef.

Gerald Durrell, *Golden Bats and Pink Pigeons*

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The Alternate View

CHANGE: THE NEW FACTOR

G. Harry Stine

"Despite the drastic changes all around us, it is remarkable how rare is the sense of newness. Perhaps to feel that something is really new we have first to expect it. It is the realization of the expected that strikes us as the birth of the new."

Thus writeth the longshoreman philosopher, Eric Hoffer.

We're not living in an age of technology—oftimes called the Space Age, the Nuclear Age, the Computer Age, etc., etc.—but an Age of Change. Most people don't believe it's real. They think it can't go on and/or that the world will eventually collapse because of change. This is probably because of two things: (1) change itself is a new factor in human affairs, and (2) the *rate of change* is also changing.

Pulitzer prize winner Daniel J. Boorstin—who also happens to be the Librarian of Congress—points out in his 1976 book, *The Exploring Spirit* (Random House, 1976, ISBN 0–394–40602–8), "The great awakening of modern man was his finding out that life was not really as repetitious as it had always seemed. This proved to be one of the most difficult steps in human development." He observed that our ancestors lived in an Age of Again-and-Again. Ecclesiastes 1:9, "The thing that hath been, it is that which shall be; and that which is done is that which shall be done; and there is no new thing under the sun." Nomadic and agricultural peoples know that the familiar is another name for security because without the familiar rising of the sun and the seasonal changes, there's no grain for food or animal skins and fibers for clothing. Even among agricultural people today, the good and the familiar seem to be one. The unfamiliar, the strange, and the different are thought to be caused either by miracles or catastrophes.

And because most of us are only a few generations removed from our agricultural ancestors, we continue to think in these same patterns.

Although it's difficult to pinpoint a moment in the past when change became an important factor in human affairs—for example, the Renaissance really brought to Europe a revised sense of time—the trend curves based on the cubic function ($y = x^3$) began drastically to increase their slopes between 1750 and 1850 when change itself was first noticed.

Most people want to go back to a world of Again-and-Again, a "perfect" world of security based primarily upon tradition with no room or need for improvement or innovation, a world in which one has only to do the same thing one's parents did. But a few of us (readers of this magazine, mostly, although

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not all of them, either) don't. Living in a changeless world isn't the way to survive, as the dinosaurs discovered, because with that outlook one cannot cope with what we now know to be a universe of change.

The world of Again-and-Again changes only because of miracles or catastrophes. And because of the new factor of change in our culture, people still believe in and yearn for both miracles and catastrophes. Think not? Simply read most of what sells well today as "science fiction," the literature of the future! (Is this an indictment? If the shoe fits, don't go barefoot.)

People are learning how to handle change, but it's a slow process of trial and error because most of what we must *unlearn* is deeply ingrained in our puritanical civilization which evolved from a world of scarcity. An example of something we've had to unlearn is the New England dictum, "Wear it out, use it up, make it do, or do without." The mere idea of *throwing away* a Timex wristwatch because it costs more to repair it than to buy a new one bothers people for whom any personal timepiece was once a treasure; the gold retirement watch is a remnant of this thought pattern. It costs more to repair a modern Japanese 35-mm single-lens reflex camera than to buy a new one. And sometimes one must buy a new device because parts to repair the old one are no longer available.

This is primarily because of the philosophy of mass production technology stemming from the First and Second Industrial Revolutions, said technologies making the cost of labor the largest part of the cost of a product. As a result, there's a trade-off that must be made: the amount of personal *time* that must be spent to repair something versus the amount of money (cost of someone else's time to make a new one) required to buy a replacement. Because of this trade-off, *all* modules aren't intended to be replaced when they need repair; only the small and inexpensive modules are discarded because one can usually afford to replace the fuel pump but not the automobile.

This also resulted in another major change in our thinking: A device should be used to save time and require very little time for maintenance and repair. And if it ain't broke, don't "fix" it.

Some people have gotten hooked on "fixing" things that aren't broken or "improving" things that are working as reasonably well as current technology will permit. This is especially true in those human endeavors where the Scientific Method, engineering, troubleshooting techniques, and solid values aren't utilized. Examples: Politics and other "social sciences," including the "arts." (In spite of the fact that I take pot shots herein at the social sciences and the arts from time to time doesn't necessarily mean I'm agin 'em; I object to their practitioners' attributing scientific or technical characteristics to them in an unjustifiable manner.)

However, once one accepts that we're living in an Age of Change, one often finds it difficult to comprehend the *rate of change of change* (the second derivative, for those who have a working knowledge of mathematics, the mother of sciences) to say nothing of the change in *that* rate of change (the third derivative).

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Most people—and I must include some science fiction authors and readers in this category—simply do not understand the magnitude of the rate of change that's taking place *right now*.

For example, in the next thirty-day period, the following changes will occur:

- 5,991 new patents will be granted,
- 1,987 new trademarks will be registered,
- 670 new products will be announced,
- 26,620 new businesses will be incorporated,
- 1,080 existing businesses will close their doors,
- 84 companies will disappear through merger,

Next year, the numbers will be different; they will be bigger.

According to the telephone company (AT&T, GTE, or whatever, take your pick—because they're changing too), in the next 12-month period, any community in the United States will experience a 30% change based on the installation of new, disconnected, and moved telephones.

Dun and Bradstreet, the ubiquitous company that keeps track of and rates the creditability of business firms, makes more than 10,000 changes *per week* in its data base.

One of the most valuable commercial data bases in the United States is known as Thomas Register. It lists and categorizes all commercial firms in the USA in terms of product(s) or service(s) produced. It lists the presidents, sales contacts, office and plant addresses, and telephone numbers of all these firms. It's important to have the latest edition because Thomas Register now incorporates more than a million changes per year.

There's something more useless than yesterday's newspaper: the most recent catalog.

Or the parts list because (*a*) some of the parts are no longer made, and (*b*) the parts numbers have all been changed.

And, inevitably, the price list, too.

The concept that change is the only constant of the universe is now reasonably well accepted by enough people to make a difference. This concept has also drastically altered the human view of our formerly changeless environment. We now *look for* change and attempt to divine the cause. Sober scientific investigation has reported that (surprise, surprise!) each and every sunset is a dynamic event that's different from each preceeding sunset. (And we didn't have this sort of crazy weather before they started putting them emission control things on automobiles, either.) And, since it's possible with a very large computer having a very large memory and capable of very fast switching time to find a correlation of everything with anything else, some of our rationales will turn out to be highly amusing to our progeny.

(Remember the old story about the million chimpanzees pounding at random on a million typewriters for a million years and thus recreating all the great literature of the world? Chimps are too slow; it can now be done in much less time with computers.)

But the new factor of change has *not* been accepted by many people who learned how to do one thing—run a lathe, mine copper, assemble automo-

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bile differentials, make vacuum tubes, etc.—and expect to do that for the rest of their working lives until they can retire to Sun City to play golf and listen to Glenn Miller records. (Item: I happen to like golf and Glenn Miller, but other things, too.) Some of these people cannot accept change and therefore cannot learn new things. To them, change is an evil and perhaps even sinful thing. (Sin: An unsuccessful way of doing something.) However, their number will eventually diminish through attrition in spite of efforts of governments and unions to preserve things that cannot be saved. Other people will accept the fact that they're going to have to change to handle change, and they'll change with the times (as many of them are now indeed doing, all on their own). Darwin was right; in a world of change, it's the survival of the fittest, which means the survival of those who have the capability to change. Again, the dinosaurs should have taught us this.

And we'd better be teaching the upcoming generation how to live with change and use it to their benefit. Unfortunately, except for a program called "Visions of the Future" (about which more in a later column), very few school systems are teaching children how to think about and cope with the future. And how to go about handling the problems caused by change.

Yes, change has caused as many problems as it has created benefits. Change is something new in human experience, although it was really there all along. How much of your everyday living problems can be attributed to change? Are you coping with change or resisting it? If you're resisting it, how long do you believe you can fight the universe? Remember: it's not nice to fool Mother Nature; it's impossible.

Of course, tomorrow that may change, too. ■

IN TIMES TO COME

Back in the late Sixties, with real exploration of space revolutionizing our knowledge of our own Solar System, science fiction writers seemed to be avoiding setting their stories that close to home. My impression was that they were afraid to use locales whose descriptions were quite likely to be proved dramatically obsolete between writing and press time. I know I was—my first story, written in 1968, was set largely on Mars, and I distinctly remember a pronounced feeling of going out on a shaky limb with my first venture into print.

However, a lot of the revolutionizing has happened, the pace of exploration has slowed for the moment, and we have a whole new picture of the Solar System to play with. Some writers have begun taking advantage of all this new knowledge, bringing their stories "back home" and exploring the wealth of new possibilities opened up by new data. Grant Callin has been doing this systematically, working his way through the planets as we now know them in a whole series of highly entertaining and scientifically solid adventures. You've seen a couple of them already, and next month Grant gets the cover (by David Hardy) for "Saturn Alia." I suppose you could call it a very distant descendant of *Treasure Island,* but the "treasure map" and the action it stirs up are thoroughly different from anything Robert Louis Stevenson could have imagined—and lots of fun.

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THE MAN CROUCHING IN THE CORNER

The concept of relativity applies to a lot of things— some of which are not obvious because we seldom get a chance to compare.

Rick Conley

"At ease, Captain. This is the Oval Office, not the parade grounds at West Point."

"Y-yes, sir."

From behind his massive desk the president studied the anxious young officer with a mixture of curiosity and contempt.

"So you're the man who captured a flying saucer?"

"Yes, sir."

"And then let it get away!"

"Yes, sir. But I can explain, sir."

"Well, that's why you're here, isn't it? You've refused to talk to the people at NASA or even to your own base commander. You insisted you'd speak only to me, didn't you?"

"Yes, sir."

"Then drop the damned 'yes-sirs' and speak!"

"Yes, sir! Uh, I mean . . ." The young officer took a deep breath, then: "Yesterday, sir, at 1600 hours Moun-

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tain Standard Time, an object initially presumed to be a conventional aircraft crashed in the hills just beyond Dry Wells Army Depot, in central New Mexico. The depot commander ordered me to mount a routine search-and-rescue mission. I secured two medics, four nurses, and the standard complement of—"

The president held his hand aloft as a sign of impatience.

"Captain, I'm aware of the mechanics of the operation; unlike you, the other members of the rescue team agreed to be debriefed immediately after the episode. However, the one thing they couldn't explain—but you can—is why you acted as you did.

"At the crash site you discovered your 'conventional' aircraft was a full-fledged flying saucer. Yet you did not immediately notify the depot of what might have been a windfall for our scientists and engineers. Nor did you request armed troops to secure a potential threat to national defense.

"Instead you alone approached the saucer, and apparently oblivious to your fellow soldiers, stared at it for a good ten or twelve minutes. Then you ordered your people to withdraw, at which time the vehicle managed to lift off.

"Captain, just what did you think you were doing?"

"I—I was listening, sir. To the, uh, people inside the saucer."

The president leaned forward. "They spoke to you?"

"Uh, no, sir. Not to me directly. It's more like I 'eavesdropped' on them. And I didn't exactly hear them speak, Mr. President; I heard them think."

"Telepathy?"

The officer shrugged. "I guess that's what you call it, sir. All I know is, I felt like I was there, in the saucer, thinking what they thought, feeling what they felt."

"But Captain, no one else reported such an experience."

"Maybe it just happened to me because I was closest to the saucer. Or maybe because . . . because I'm me. I don't know, sir."

"These *people* inside—do you think they could read *your* thoughts?"

"I don't know that either, sir. If they could, then they must have sensed in me what I sensed in them: fear . . . confusion."

"They were afraid, Captain?"

"Most of them, sir. Afraid. Depressed. Although I did sense among them some figures of authority, trying to reassure them, promising them that they'd soon be lifting off again.

"That's why I didn't try to secure the ship, Mr. President. I was convinced there wasn't time."

The president nodded.

"But what else, Captain? What did you 'overhear' that you couldn't tell anyone but me?"

The officer seemed to study the presidential seal in the carpet for a few moments. Then: "I found out why they came here. I found out why their ships routinely visit Earth but never contact us."

"Yes, Captain?"

The young man swallowed hard.

"Sir, have you ever spent time in a military hospital?"

The president shook his head.

"Two years ago, sir, while I was a military advisor in El Salvador, I stepped

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on a land mine. I woke up stateside in a military hospital. The doctors said I'd walk again, but they had more confidence in me than I had. I resisted physical therapy and just stayed in bed feeling sorry for myself.

"Then one day a shrink—uh, a psychiatrist dumped me into a wheelchair and rolled me into another ward for a few minutes. He pointed out to me a Vietnam vet who was flat on his back in bed with all kinds of tubes stuck in him. The shrink said the poor guy had been that way for years and probably wouldn't get any better. Then he said to me, 'Do you really think you're so bad off?'

"I got the message. I started taking the physical therapy seriously, and three months later I walked out of that hospital under my own steam."

"Son, I'm glad that you recovered, but I don't quite see what this has to do with—"

"Mr. President, before I was discharged from the hospital, I visited the guy in the bed. Naturally I didn't tell him how the shrink had used him as an example for me.

"He must have sensed I was feeling sorry for him, though, because he told me not to. He said he used to feel sorry for himself; but one day a shrink showed him pictures of some poor guy in the psycho ward, crouching in the corner and drooling all over himself. After that he said he realized he wasn't as bad off as some people; at least he could read and talk and watch TV. He felt a lot better."

"Effective psychology," the president concluded. " 'I cried because I had no shoes until I met a man who had no feet.' But, Captain, I still don't understand—"

"Mr. President, I said the people in the saucer were afraid, confused. They were. And depressed, too. But not just because of the crash.

"I sensed that they were sick—emotionally crippled. They didn't seem to have any more confidence in themselves than I had had in myself just after my injury. That's why they were taking therapy."

"Therapy?"

"The saucers, Mr. President—they're hospital ships. They routinely visit Earth to show their patients the mess we've made of things—the pollution, the crime, the war. We humans are living proof to these poor, sick creatures that they could be worse off: they could be like us.

"You see, Mr. President, we're the man crouching in the corner." ■

● A life which does not go into action is a failure; and this is just as true of a prophet's, a poet's, or a scholar's life as it is true of the life of a "man of action," in the conventionally limited popular usage of the term.

Arnold J. Toynbee, *A Study of History*

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On Gaming

Dana Lombardy

Anne McCaffrey's series of novels on Pern, a distant world colonized by Earthmen and inhabited by fire-breathing dragons, have been translated into a board game. *Dragonriders of Pern* is published by Mayfair Games Inc. ($17 at your local store, or direct from Box 5987, Chicago, IL 60680).

One great threat to Pern occurs every several hundred years: a bright Red Star with an erratic orbit comes close to Pern, and the star's indigenous life form, called Thread, attempts to invade the more temperate and hospitable Pern.

Thread is a space-travelling mycorrhizoid spore that devours all organic matter it touches, and, once on the ground, burrows and proliferates with amazing speed.

The early colonists were almost wiped out by the first falling of Thread on Pern. Survivors sought to control future attacks of Thread by using Pern's indigenous fire lizards, called "dragons" by the descendents of the colonizers from Earth. These domesticated flying dragons breath fire after chewing a phosphine-bearing rock, and can jump forward and backward in time.

When Thread fall, the dragonriders fly into action, scorching the Thread in mid-air before it can reach the ground to do damage.

The game starts at a time when the Red Star has reappeared but the dragonriders have dwindled to just a handful after many years of no attacks by Thread. Only one Weyr remains, a Weyr being the large caverns (such as extinct volcanoes) where the dragons and their riders live.

There are two main games in *Dragonriders of Pern:* a basic or introductory game with four pages of rules, and an advanced game with five additional pages of rules and charts. There's also a solitaire game, notes on tactics and organization of the dragonriders, a glossary of terminology, designer's notes, and an introduction written by Anne McCaffrey.

Up to six people can play the game. In addition to the rules, components include: a 19- by 23-inch game board painted by fantasy artist Tim Hildebrandt; 112 playing cards for events, personalities, and Threadfall; 108 markers representing a flight of dragons, Weyrleaders, Marks (money), etc.; and three six-sided dice.

The primary goal of the players is the protection of Pern. If enough Thread land on Pern, the planet is ravaged and cannot support life, and all players lose. If the players are successful in fighting Thread, then the player with the most allied Lord Holders (the controllers of the cities and territories of Pern) is the winner.

The game map shows the northern (populated) continent of Pern, the 6 Weyrs, the 15 major Holds, 27 minor Holds, and 11 crafthalls (representing the major skills or "crafts," such as fishing, farming, etc.).

Diplomacy is the most important element in the game. After the Weyrs have

(continued on page 163)

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THE PEACE WAR

Part Two of Four

Vernor Vinge

The bobbles were new and some found them useful. But when a technology is new enough, it may still hold startling surprises even for its creators. . . .

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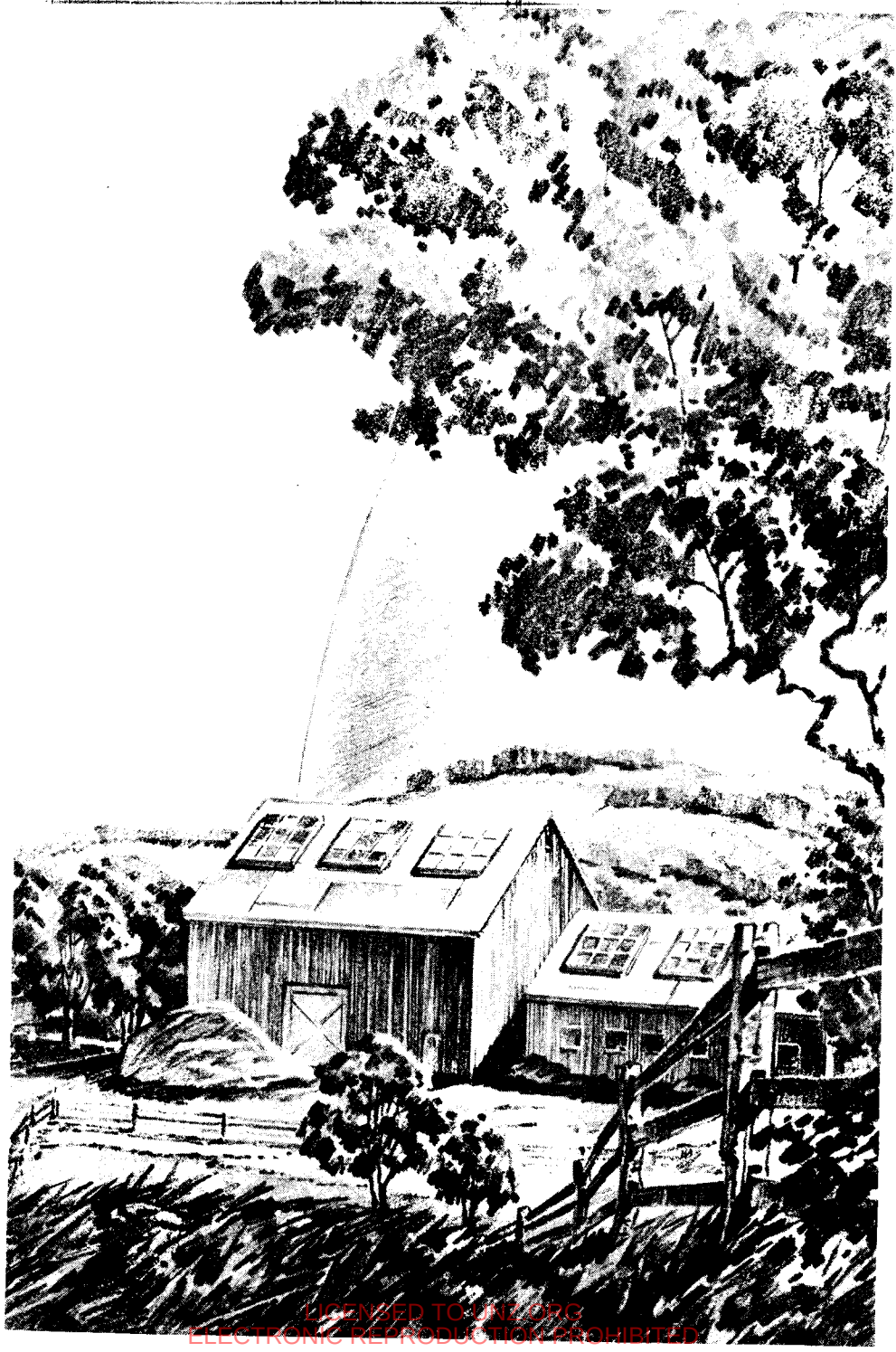

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SYNOPSIS

Sometimes the consequences of an invention take a long time to be understood. Next to computers, **bobbles** *may be the all-time winner in this department. Their surprise use in the 1997 war brought the end of the national governments, but it was fifty years before anyone understood their real significance.*

It might be argued that Captain **Allison Parker**, *USAF, was the first to see the truth. On 1 July 1997, she was returning to Vandenberg AFB from a "quick look" orbital mission. Her survey had found nothing new in the Soviet bloc, but she had seen something she didn't understand. Over California, she had probed the new labs at Livermore. Something absolutely reflective lay below ground there—as predicted by her friend* **Paul Hoehler**, *an employee at the labs. And it was reports from those labs that had started the current war scare. . . .*

Telling the story of bobbles raises merry hell with synchronicity. If you follow one person's viewpoint, the story may get too far ahead of itself. If you try for a strict, real-time chronology, the story breaks into disconnected fragments.

So, Allison first:

With no perceptible transition, the orbiter was on the ground, burning. Allison and the surviving pilot, **Angus Quiller**, *climbed from the wreck with the record Parker had made of the recon. Seconds later the orbiter exploded, sending a metal fragment through Allison's leg. They were down in a rain forest. The only evidence of other humans was a stone cross at the edge of the crash site. The cross bore one name: "Allison Parker."*

Now the strict, real-time chronology:

During the hours following the reentry of Allison's orbiter, military sites in both Soviet and Western camps came under attack—or simply stopped reporting. General war followed, but only a few nuclear weapons were used. Both sides were mystified by the strange silvery bubbles, baubles—bobbles?—that were springing up, enclosing bombs and delivery systems, military bases and fleets.

With this chaos far advanced, one of the contract labs at Livermore announced itself as the maker of the bobbles and the new guardian of peace—a **Peace Authority**. *Sovereign governments were no longer to be tolerated. Enemies of the Peace were subject to embobblement: The spherical force fields were impenetrable and theoretically eternal. To be trapped inside was clearly a sentence of death by asphyxiation.*

The war plagues began shortly after the Peace Authority announced itself. This was—Authority commentators said—the last attempt of the governments to regain power. It did not succeed, but for two decades the plagues spread out of control. Billions died. Fertility dropped to near zero.

And the authority of the Peace grew.

The '30s and '40s were the high years of the Peace. The entire planet was under its control. The situation in the American West was typical: California south of Santa Barbara was Spanish-speaking, a collection of feudal domains known as **Aztlán**. *Northwards spread the* **ungoverned lands**, *kept in a state of anarchy. Across the old USA missile*

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fields lay hundreds of bobbles—testament to the destruction which the Peace had averted. Much larger bobbles enclosed the military bases of the old regime. The one around Vandenberg AFB was twenty kilometers across, its upper hemisphere reaching 10,000 meters into the sky. So vast and reflective was the dome that the local climate was changed. Rainfall surpassed 250 centimeters per year. Banana and cocoa production became feasible.

The Authority might have gone unchallenged, if not for an unlikely alliance: In 2047, **Wili Wachendon** *was fifteen—and looked eleven. Wili was a first-rank genius, but had plenty of compensating problems. He suffered from one of the wasting diseases that were the legacy of the plague years. Nearly feral, he had grown up on the fringes of the black ghetto in LA, the* **Ndelante Ali.**

Paul Naismith *was almost eighty, and the most important* **Tinker** *on the West Coast. As in other dark ages, technical progress had not entirely stopped. The Peace had Banned heavy manufacturing, but low-power electronics survived as a cottage industry. In some ways, the Tinkers had taken electronics as far as it might have gone* without *the war and plagues—though the Directors of the Authority were only beginning to realize this.*

Naismith hated the Authority, and in unguarded moments hinted darkly at secret knowledge of the Peace's origin. When he found Wili Wachendon, the aged genius recognized the child genius, and realized that here might be a powerful weapon in his lifelong battle.

At first their alliance rested on mutual deception. There was some force used (and even a little blood spilled) before Wili realized what his mind could do with the knowledge Naismith offered. After that, Wili couldn't imagine the partnership broken. They spent the fall and winter at Naismith's hidden home in the mountains east of Vandenberg. Starting with what arithmetic Wili knew, the boy proceeded quickly (like all high-order math geniuses) to the frontiers.

And all through the winter, Wili's health declined. With the spring he recovered, but Naismith realized the boy could not last more than another year or two. Unless something was done:

Naismith supplied algorithms to Tinkers across North America; people owed him. Now he called in those debts, and demanded that the Tinkers get Wili in touch with the bioscience underground. This was asking a lot, since the Tinkers—like almost everyone in the '40s—blamed the bioscientists for the plagues. **Miguel Rosas**, *Naismith's contact in Santa Ynez, was especially reluctant. Nevertheless, Naismith squeezed hard, pointing out that Wili had already discovered how to eavesdrop on Peacer recon satellites (a capability the Tinkers had long desired). In the end Naismith prevailed, and plans were made for getting Wili to a secret biolab near San Diego.*

By the spring of 2048, things were heating up for the Peace. The Authority's Directors were beginning to realize that bobbles are not forever: several ten-meter bobbles had already lapsed. After the destruction of Tucson, these events could not be concealed. Authority Director **Hamilton Avery** *was forced to give an explanation to the leaders of*

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Atlazán and the Republic of New Mexico: "Bobbles are subject to quantum decay, with half-life proportional to size. Nothing to worry about, unless the bobble happens to contain an exploded nuke." Privately, Avery feared that someone had discovered how to burst bobbles. He had strong suspicions the Tinkers were behind it all.

Meanwhile, Wachendon and Naismith traveled to a Tinker farm near Vandenberg Dome. They were accompanied by **Jeremy Sergeivich Kaladze**, *the teen-age grandson of the farm's founder. As they walked through the rain forest surrounding the Dome, Naismith realized they were being followed. He led the boys off the main trail, along a path Jeremy had thought a Kaladze secret. Eventually, they reached a long crater gouged by a twenty-meter bobble. Wili bumped against something hard and artificial, a cemetary cross.* Now why would something like that be here?

They took the high ground behind the bobble and listened to the bandits approach.

11

The bandits' rifle fire lit the trees. There came another volley and another. Wili heard Jeremy move, as if getting ready to jump up and return fire. He realized the Russians must be shooting at themselves. The reflection that had fooled him had taken them in too. What would happen when they realized it was only a bobble that faced them? A bobble and one rifle in the hands of an incompetent marksman?

The gunfire came to a ragged stop. "Now, Jeremy!" Naismith said. The larger boy jump into the open and swung his weapon wildly across the ravine. He fired the whole clip. The rifle stuttered in an irregular way, as though on the verge of jamming. Its muzzle flash lit the ravine. The enemy was invisible, except for one fellow vaguely seen against the light colored rock at the side of the cleft. That one had bad luck: He was almost lifted off his feet by the impact of bullet on chest, and slammed back against the rock.

Cries of pain rose from all along the ravine. How had Jeremy done it? Even one hit was fantastic luck. And Jeremy Kaladze was the fellow who in broad daylight could miss the side of a barn.

Jeremy slammed down beside him. "Did I g-get them all?" There was an edge of horror in his voice. But he slipped another clip into his sawed-off weapon.

There was no return fire. But wait. The bandit lying by the outcrop—he was up and running! The hit should have left him dead or crawling. Through the bushes below, he could hear the others picking themselves up and running for the far end of the ravine. One by one, they appeared in silhouette, still running.

Jeremy rose to his knees, but Naismith pulled him down.

"You're right, son. There's something strange with them. Let's not press our luck."

They lay for a long time in the ringing silence, till at last the animal sounds resumed and the starlight seemed bright. There was no sign of humans inside of five hundred meters.

"Projections?" Jeremy wondered

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aloud. *Zombies?* Wili thought silently to himself. But they could be neither. They had been hit; they had gone down. Then they had gotten up and run in a panic—and that was unlike the zombies of Ndelante legend. Naismith had no speculations he was willing to share.

It was raining again by the time their rescuers arrived.

Only 9 o'clock on an April morning and already the air was a humid 30 degrees. Thunderheads hung high on the arch of the Dome. It would rain in the afternoon. Wili Wachendon and Jeremy Sergeivich Kaladze walked down the wide, graveled road that led from the main farmhouse toward outbuildings by the Dome. They made a strange sight: One boy near two meters tall, white and lanky; the other short, thin and black, apparently subadolescent. But Wili was beginning to realize that there were similarities, too. It turned out they were the same age—fifteen. And the other boy was sharp, though not in the same class as Wili. He had never tried to intimidate with his size. If anything, he seemed slightly in awe of Wili (if that were possible in one as rambunctious and outspoken as Jeremy Sergeivich).

"The Colonel says,"—Jeremy and the others never called Old Kaladze "Grandfather," though there seemed to be no fear in their attitude, and a lot of affection,—"the Colonel says the farm is being watched, has been since the three of us got here."

"Oh? The bandits?"

"Don't know. We can't afford the equipment Dr. Naismith can buy—those micro-cameras and such. But we have a telescope and twenty-four hour camera on top of the barn. The processor attached to it detected several flashes from the trees," he swept his hand toward the ridgeline where the rain forest came down almost to the farm's banana plants, "that are probably reflections from old-style optics."

Wili shivered in the warm sunlight. There were lots of people here compared to Naismith's mansion in the wilderness, but it was not a properly fortified site: There were no walls, watch towers, observation balloons. There were many very young children and most of the adults were over fifty. That was a typical age distribution, but one unsuitable for defense. Wili wondered what secret resources the Kaladzes might have.

"So what are you going to do?" Wili asked.

"Nothing much. There can't be too many of 'em; they're awful shy. We'd go out after them if *we* had more people. As it is, we've got four smart rifles and men who can use them. And Sheriff Wentz knows about the situation . . . c'mon, don't worry." He didn't notice Wili bristle. The smaller boy hid it well. He was beginning to realize that there was scarcely a mean bone in Jeremy's body. "I want to show you the stuff we have here."

He turned off the gravel road and walked toward a large, one-story wood building. It could scarcely be a barn; the entire roof was covered with solar batteries. "If it weren't for the Vandenberg Bobble, I think Middle California would be most famous for Red Arrow Products—that's our trade name. We're not as sophisticated as the Greens in Norcross, or as big as the Qens in Beijing, but the things we do are the best."

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Wili pretended indifference. "This place is just a big farm, it looks like to me."

"Sure, and Dr. Naismith is just a hermit. It is big and it's terrific farmland. But where do you think my family got the money to buy it? We've been real lucky: Grandmother and the Colonel had four children after the War, and each of them had at least two. We're practically a clan and we've adopted other folk, people who can figure out things we can't. The Colonel believes in diversification; between the farm and our software, we're unsinkable."

Jeremy pounded on the heavy white door. There was no answer, but it swung slowly inward and the boys entered. Down each side of the long building, windows let in morning light and enough breeze to make it relatively comfortable. He had an impression of elegant chaos. Ornamental plants surrounded scattered desks. There was more than one aquarium. Most of the desks were unoccupied: Some sort of conference was going on at the far end of the room. The men waved to Jeremy, but continued with what sounded perilously close to being an argument.

"Lots more people here than usual. Most guys like to work from home. Look." He pointed to one of the few seated workers. The man seemed unaware of them. In the holo above his desk floated colored shapes, shapes that shifted and turned. The man watched intently. He nodded to himself and suddenly the pattern was tripled and sheared. Somehow he was in control of the display. Wili recognized the composition of linear and nonlinear transformations: inside his head, Wili had played with those through most of the winter.

"What's he doing?"

Jeremy's normal loudness was muted. "Who do you think implements those algorithms you and Dr. Naismith invent?" He swept his hand across the room. "We've done some of the most complicated implementations in the world."

Wili just stared at him. "Look, Wili. I know you have all sorts of wonderful machines up in the mountains. Where do you think they come from?"

Wili pondered. He had never really thought about it! His education had moved very fast along the paths Naismith laid out. One price for this progress was that in most regards Wili's opinions about what made things work were a combination of mathematical abstraction and Ndelante myth. "I guess I thought Paul made most of them."

"Dr. Naismith is an amazing man, but it takes hundreds of people all over the world to make the things he needs. Miguel Rosas says it's like a pyramid: At the top there are just a few men—say Naismith in algorithms or Masaryk in surface physics—guys who can invent really new things. With the Peace Authority Bans on big organizations, these people got to work alone and there probably aren't more than five or ten of them in the whole world. Next down in the pyramid are software houses like ours. We take algorithms and implement them so that machines can run them.

Wili watched the programmatic phantoms shift and turn above the desk. Those shapes were at once familiar and alien. It was as if his own ideas had been transformed into some strange

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form of Celest. "But these people don't *make* anything. Where do the machines come from?"

"You're right; without hardware to run our programs, we're just daydreamers. That's the next level of the pyramid. Standard processors are cheap. Before the plagues, several families from Sunnyvale settled in Santa Maria. They brought a truck-load of gamma-ray etching gear. It's been improved a lot since. We import purified base materials from Oregon. And special-purpose stuff comes from even further: For instance, the Greens make the best synthetic optics."

Jeremy started for the door. "I'd show you more here except they seem awfully busy today. That's probably your fault. The Colonel seems real excited about whatever you and Dr. Naismith invented this winter." He stopped and looked at Wili, as though hoping for some inside information. And Wili wondered to himself, *How can I explain?* He could hardly describe the algorithm in a few words. It was a delicate matter of coding schemes, of packing and unpacking certain objects very cleverly and very quickly. Then he realized that the other was interested in its *effects*, in the ability it could give one to listen to the Authority satellites.

His uncertainty was misinterpreted, for the taller boy laughed. "Never mind, I won't push you. Fact is, I probably shouldn't know. C'mon, there's one thing more I want to show you — though maybe it should be a secret too. The Colonel thinks the Peace Authority might issue a Ban if they knew about it."

They continued down the farm's main road, which ran directly into the side of the Vandenberg Dome some thousand meters further on. It made Wili dizzy just to look in that direction. This close, there was no feeling of the overall shape of the Dome. In a sense it was invisible, a vast vertical mirror. In it he saw the rolling hills of the farm, the landscape that spread away behind them: There were a couple small sail boats making for the north shore of Lake Lompoc, and he could see the ferry docked on the near side of the Salsipuedes fiord.

As they walked closer to the bobble, he saw that the ground right at the edge was torn, twisted. Rain off the Dome had gouged a deep river around the base, runoff to Lake Lompoc. The ground shook faintly but constantly with tiny earthquakes. Wili tried to imagine the other half of the bobble, extending kilometers into the earth. No wonder the world trembled around this obstruction. He looked up and swayed.

"Gets you, doesn't it?" Jeremy grabbed his arm and steadied him. "I grew up close to it, and I still fall flat on my behind when I stand here and imagine trying to climb the thing." They scrambled up the embanked mud and looked down at the river. Even though it hadn't rained for hours, the waters moved fast and muddy, gouging at the land. Across the river, a phantom Jeremy and Wili stared back. "It's dangerous to get much closer. The water channel extends a ways underground. We've had some pretty big landslides.

"That's not why I brought you here, anyway." He led Wili down the embankment toward a small building. "There's another level in Miguel's pyramid: the folks who make things like carts and houses and plows. The refur-

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bishers still do a lot of that, but they're running out of ruins, at least around here. The new stuff is made just like it was hundreds of years ago. It's expensive and takes a lot of work—the type of thing the Republic of New Mexico or Aztlán is good at. Well, we can program processors to control moving-parts machines. I don't see why we can't make a moving-parts machine to *make* all those other things. That's my own special project."

"Yes, but that's Banned. Are you telling me—"

"Moving-parts machines aren't Banned. Not directly. It's high energy, high speed stuff the Authority is death on. They don't want anyone making bombs or bobbles and starting another War." The building looked like the one they had left up the road, but with fewer windows.

An ancient metal pylon stuck out of the ground near the entrance. Wili looked at it curiously and Jeremy said, "It doesn't have anything to do with my project. When I was little, you could still see numbers painted on it. It's off the wing of a pre-Authority airplane. The Colonel thinks it must have been taking off from Vandenburg Air Force Base at the instant they were bobbled: Half of it fell out here, and the rest crashed inside the Dome."

He followed Jeremy into the building. It was much dimmer than inside the software house. Something moved; something made high-pitched humming noises. It took Wili a second to realize that he and Jeremy were the only living things present. Jeremy led him down an aisle toward the sounds. A small conveyer belt stretched into the darkness. Five tiny arms that ended in mechanical hands were making a . . . what? It was barely two meters long and one high. It had wheels, though smaller than on a cart. There was no room for passengers or cargo. Beyond this machine aborning, Wili saw at least four completed copies.

"This is my fabricator." Jeremy touched one of the mechanical arms. The machine immediately stopped its precise movements, as though in respect to a master. "It can't do the whole job, only the motor windings and the wiring. But I'm going to improve it."

Wili was more interested in what was being fabricated. "What . . . are they?" He pointed to the vehicles.

"Farm tractors, of course! They're not big. They can't carry passengers; you have to walk behind them. But they can draw a plow, and do planting. They can be charged off the roof batteries. It's a dangerous first project, I know. But I wanted to make something nice. The tractors aren't really vehicles; I don't think the Authority will even notice. If they do, we'll just make something else. My fabricators are flexible."

They'll Ban your fabricators, too. Not surprisingly, Wili had absorbed Paul's opinion of the Peace Authority. They had Banned the research that could cure his own problems. They were like all the other tyrannies, only more powerful.

But Wili said none of this aloud. He walked to the nearest completed "tractor" and put his hand on the motor shell, half expecting to feel some electric power. This was, after all, a machine that could move under its own power. How many times he had dreamed of

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driving an automobile. He knew it was the fondest wish of some minor Jonque aristocrats that one of their sons might be accepted as an Authority truck driver.

"You know, Jeremy, this thing *can* carry a passenger. I bet I could sit here on its back and still reach the controls."

A grin slowly spread across Jeremy's face. "By golly, I see what you mean. If only I weren't so big, I could too. Why, you could be an automobilist! C'mon, let's move this one outside. There's smooth ground behind the building where we can—"

A faint *beep* came from the phone at Jeremy's waist. He frowned and raised the device to his ear. "Okay. Sorry."

"Wili, the Colonel and Dr. Naismith want to see us—and they mean right now. I guess we were expected to hang around the main house and wait on their pleasure." It was closest Wili ever heard Jeremy come to disrespect for his elders. They started toward the door. "We'll come back before the afternoon rain and try to ride."

But there was sadness in his voice, and Wili looked back into the shadowed room. Somehow he doubted he would return any time soon.

12

It might have been a council of war. Colonel Kaladze certainly looked the part. In some ways Kaladze reminded Wili of the bosses in the Ndelante Ali: He was almost eighty, yet ramrod straight. His hair was cut as theirs, about five millimeters long everywhere, even on the face. The silvery stubble was stark against his tan. His gray-green work clothes were unremarkable except for their starched and shiny neatness. His blue eyes were capable of great good humor—Wili remembered from the welcoming dinner—but this morning they were set and hard. Next to him Miguel Rosas—even armed and wearing his sheriff's brassard—looked like a loose civilian.

Paul looked the same as always, but he avoided Wili's eyes. And that was the most ominous sign of all.

"Be seated, gentlemen," the old Russian said to the boys. All his sons —except Jeremy's father who was on a sales expedition to Corvallis —were present. "Wili, Jeremy, you'll be leaving for San Diego earlier than we had planned. The Authority desires to sponsor the North American Chess Tourney much as they've sponsored the Olympics these last few years: they are providing special transportation, and have moved up the semi-finals correspondingly."

This was like a burglar who finds his victim passing out engraved invitations, thought Wili.

Even Jeremy seemed a little worried by it: "What will this do to Wili's plan to, uh, get some help down there? Can he do this right under their noses?"

"I think so. Paul thinks so." He glanced at Miguel Rosas, who was looking pointedly at the wall. "At worst, the Authority is suspicious of us Tinkers as a group. They don't have any special reason to be watching Wili. In any case, if we are to participate, our group must be ready for their truck convoy. It will pass the farm in less than fifteen hours."

Truck convoy. The boys stared at each other. For an instant, any danger seemed small. The Authority was going to let

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them ride like kings down the coast of California all the way to La Jolla! "All who go must leave the farm in two or three hours to reach Highway 101 before the convoy passes through." He grinned at Ivan, his eldest son. "Even if the Authority is watching, even if Wili didn't need help, Kaladzes would still be going. You boys can't fool me. I know you've been looking forward to this for a long time. I know all the time you've wasted on programs you think are unbeatable."

Ivan Nikolayevich seemed startled, then smiled back. "Besides, there are people there we've known for years and never met in person. It would be even more suspicious if we pulled out now."

Wili looked across the table at Naismith. "Is it okay, Paul?"

Suddenly Naismith seemed much older even than the Colonel. He lowered his head and spoke softly. "Yes, Wili. It's our best chance to get you some help. . . . But Miguel will go instead of me. I can't come along. You see—"

Paul's voice continued, but Wili heard no more. *Paul will not come. This one chance to find a cure and Paul will not come.* For a moment that lasted long inside his head, the room whirled down to a tiny point and was replaced by Wili's earliest memories:

Claremont Street, seen through an unglazed window, seen from a small bed. The first five years of his life he had spent most of every day in that bed, staring out into the empty street. Even in that he had been lucky. At that time Glendora had been an outland, beyond the reach of the Jonque lords and the milder tyranny of the Ndelante Ali. Wili, those first few years, was so weak he could scarcely eat even when food was right at hand. Survival had depended on his uncle Sly. If he still lived, Sylvester would be older than Naismith himself. When Wili's parents wanted to give their sickly newborn to the coyotes and the hawks, it had been Uncle Sly who argued and pleaded and finally persuaded them to abandon Wili's worthless body to him instead. Wili would never forget the old man's face—so black and gnarled, fringed with silver hair. Outside he was so different from Naismith, inside so like him.

For Sylvester Washington (he insisted on the Anglo pronunciation of his last name) had been over thirty when the War came. He had been a school teacher, and he would not give up his last child easily. He made a bed for Wili, and made sure it faced onto the street so that the invalid boy could see and hear as much as possible. Sylvester Washington talked to him hours every day. Where similar children wasted and starved, Wili slowly grew. His earliest memories, after the view of Claremont Street through the window hole, were of Uncle Sly playing number games with him, forcing him to work with his mind when he could do nothing with his body.

Later the old man helped the boy exercise his body, too. But that was after dark, in the dusty yard behind the ruin he called their "ranch house." Night after night, Wili crawled across the warm earth, till finally his legs were strong enough to stand on. Sly would not let him stop till he could walk.

But he never took him out during the day, saying that it was too dangerous.

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The boy didn't see how. The street beyond his window was always quiet and empty.

Wili was almost six years old when he found the answer to that mystery, and his world ended: Sylvester had already left for work at the secret pond his friends had built above of the Ndelante irrigation project. He had promised to come home early with something special, a reward for all the walking.

Wili was tired of the terrible daytime heat within the hovel. He peered through the crooked doorway and then walked slowly out onto the street, reveling in his freedom. He walked down the empty street, and suddenly realized that a few more steps would take him to the intersection of Claremont and Catalina—and beyond the furthest reach of his previous explorations. He wandered down Catalina for fifteen or twenty minutes. What a wonderland: vacant ruins dessicating in the sun. They were of all sizes, and of subtly different colors depending on the original paint. Rusted metal hulks sat like giant insects along one side of the street.

More than one house in twenty was occupied. The area had been looted and relooted. But—as Wili learned in later adventures—parts of the Basin were still untouched. Even fifty years after the War there were treasure hoards in the farthest suburbs. Aztlán did not claim a recovery tax for nothing.

Wili was not yet six, but he did not lose his way; he avoided houses that might be occupied and kept to the shadows. After a time he tired and started back. He stopped now and then to watch some lizard scurry from one hole to another. Gaining confidence, he cut across a grocery store parking lot, walked under a sign proclaiming bargains fifty years dead, and turned back onto Claremont. Then everything seemed to happen at once.

There was Uncle Sly, home early from the pond, struggling to carry a bag slung over his back. He saw Wili and his jaw fell. He dropped the bag and started running toward the boy. At the same time the sound of hooves came from a side alley. Five young Jonques burst into the sunlight—labor raiders. One swept the boy up while the rest held old Sly off with their whips. Lying on his belly across the saddle, Wili twisted about and got one last look. There was Sylvester Washington, already far down the street. He was wringing his hands, making no sound, making no effort to save him from the strange men who were taking Wili away.

Wili survived. Five years later he was sold to the Ndelante Ali. Two more years and he had some reputation for his burgling. Eventually, Wili returned to that intersection on Claremont street. The house was still there; things don't change suddenly in the Basin. But the house was empty. Uncle Sly was gone.

And now he would lose Paul Naismith, too.

The boy's walleyed stare must have been taken for attentiveness. Naismith was talking, still not looking directly at Wili. "You are really to thank for the discovery, Wili. What we've seen is . . . well, it's strange and wonderful and maybe ominous. I *have* to stay. Do you understand?"

Wili didn't really mean the words, but they came anyway. "I understand you won't come along. I understand

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some silly piece of math is more important."

Worse, the words didn't anger Paul. His head bowed slightly, "Yes. There are some things more important to me than any person. Let me tell you what we saw—"

"Paul, if Miguel and Jeremy and Wili are to be in the mouth of the lion, there is no sense in their knowing more right now."

"As you say, Kolya," Naismith rose and walked slowly to the door. "Please excuse me."

There was a short silence, broken by the Colonel. "We'll have to work fast to get you three on the way in time. Ivan, show me just what your chess fans want to send with Jeremy. If the Authority is providing transport, maybe Miguel and the boys can take a more elaborate processor." He departed with his sons and Jeremy.

That left Wili and Miguel. The boy stood and turned to the door.

"Just a minute, you." Miguel's voice had the hard edge Wili remembered from their first encounter months before. The undersheriff came around the table and pushed Wili back into his chair. "You think Paul has deserted you. Maybe he has. But from what I can tell, they've discovered something more important than the lot of us. I don't know exactly what it is, or I couldn't go with your and Jeremy, either. Get it? We can't afford to let Naismith fall into Authority hands.

"Consider yourself damn lucky we're going through with Paul's harebrained scheme to get you cured. He's the only man on Earth who could've convinced Kaladze to deal even indirectly with the bioscience swine." He glared down at Wili, as if expecting some counterattack. The boy was silent and avoided his eyes.

"Okay. I'll be waiting for you in the dining house." Rosas stalked out of the room.

Wili was motionless for a long time. There were no tears; there had been none since that afternoon very long ago on Claremont Street. He didn't blame Sylvester Washington and he didn't blame Paul Naismith. They had done as much as one man can do for another. But ultimately there is only one person who can't run away from your problems.

13

Still five meters up, the twin rotor chopper sent a shower of grit across the Tradetower helipad. From her place in the main cabin, Dellu Lu watched the bystanders grab their hats and squint into the wash. Old Hamilton Avery was the only fellow who kept his aplomb.

As the chopper touched down, one of her crew slid open the front hatch and waved at the standing VIPs. Through her silvered window, she saw Director Avery nod and turn to shake hands with Smythe, the LA franchise owner. Then Avery walked alone toward the crewman, who had not stepped down from the doorway.

Smythe was probably the most powerful Peacer in Southern California. She wondered what he thought when his boss submitted to such a cavalier pickup. She smiled lopsidedly. Hell, she was in charge of the operation, and she didn't know what was coming off either.

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The rotors had not spun down when she heard the hatch slam. Her crew had their orders: The helipad dropped away as the chopper rose like some transcendental elevator from the top of the Tradetower. They slid out from the roof and she looked down eighty storeys at the street.

As the helicopter turned toward LAX and Santa Monica, Della came to her feet. An instant later Avery entered her cabin. He looked completely relaxed yet completely formal, his dress both casual and expensive. In theory the Board of Directors of the Peace Authority was a committee of equals. In fact, Hamilton Avery had been the driving force behind it for as long as Della Lu had been following inner politics. Though not a famous man, he was the most powerful in the world.

"My dear! So good to see you." Avery walked quickly to her, shook her hand as he might an equal and not an officer three levels below him. She let the silver-haired director take her elbow and lead her to her seat. One might think she was his guest.

They sat down, and the director looked quickly about the cabin. It was a solid, mobile command room. There was no bar, no carpets. With her priority, she could have had such, but Della had not gotten to her present job by sucking up to her bosses.

The aircraft hummed steadily westward, the chop of the blades muted by the office's heavy insulation. Below, Della could see Peace Authority housing. The Enclave was really a corridor that extended from Santa Monica and LAX on the coast, inland to what had once been the center of Los Angeles. It was the largest enclave in the world. More than fifty thousand people lived down there, mostly near the News Service studios. And they lived well. She saw swimming pools and tennis courts on the three acre suburban lots that passed below.

In the north glowered the castles and fortified roads of the Aztlán aristocrats. They had governmental responsibility for the region, but without Banned technology their "palaces" were medieval dumps. Like the Republic of New Mexico, Aztlán watched the Authority with impotent jealousy, and dreamed of the good old days.

Avery looked up from the view. "I noticed you had the Beijing insignia painted over."

"Yessir. It was clear from your message that you didn't want people to guess you were using personnel from off North America." That was one of the few things that was crystal clear. Three days before she had been at the Beijing Enclave, just returned from her final survey of the Central Asian situation. Then a megabyte of detailed instructions comes over the satellite from Livermore—and not to the Beijing franchise owner, but to one Della Lu, third level counter-guerrilla cop and general hatchetman. She was assigned a cargo jet—its freight being this chopper—and told to fly across the Pacific to LAX. No one was to emerge at any intermediate stop. At LAX, the freighter crew was to disgorge the chopper with her people, and return immediately.

Avery nodded approvingly. "Good. I need someone who doesn't need everything spelled out. Have you had

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a chance to read the New Mexico report?"

"Yessir." She had spent the flight studying the report and boning up on North America politics. She had been gone three years; there'd have been a lot of catching up to do—even without the Tucson crisis.

"Do you think the Republic bought our story?"

She thought back on the meeting tape and the dossiers. "Yes. Ironically, the most suspicious of them were also the most ignorant. Schelling bought it hook, line, and sinker. He knows enough theory to see that it's reasonable."

Avery nodded.

"But they'll continue to believe only if no more bobbles burst. And I understand it's happened at least twice more during the last few weeks. *I* don't believe the quantum decay explanation. The old USA missile fields are littered with thousands of bobbles. If decays continue to happen, they won't be missed."

Avery nodded again. He didn't seem especially upset by her analysis.

The chopper did a gentle bank over Santa Monica, giving her a close-up view of the largest mansions in the Enclave. She had a glimpse of the Authority beach and the ruined Aztlán shoreline further south, and then they were over the ocean. They flew south several kilometers before turning inland. They would fly in vast circles until the meeting was over. Even the Tuscon event could not explain this mission. Della almost frowned.

"What you say is correct," Avery said, "but it may be irrelevant. It depends on what the true explanation turns out to be. Have you considered the possibility that someone has discovered how to destroy bobbles; that we are seeing their experiments?"

"The choice of 'experiment sites' is very strange, sir: the Ross Iceshelf, Tucson, Ulan Ude. And I don't see how such an organization could escape direct detection."

Fifty-five years ago, before the War, what had become the Peace Authority had been a contract laboratory, a corporation run under federal grants to do certain esoteric—and militarily productive—research. That research had produced the bobbles, force-fields whose generation took a minimum of thirty minutes' power from the largest nuclear plant in the lab. The old US government had not been told of the discovery; Avery's father had seen to that. Instead, the lab directors played their own version of geopolitics. Even at the rarified bureaucratic heights Della inhabited, there was no evidence that the Avery lab had started the War, but she had her suspicions.

In the years following the great collapse, the Authority had stripped the rest of the world of high energy technology. The most dangerous governments—such as the United States—were destroyed, and their territories left in a state that ranged from the village anarchy of Middle California, to the medievalism of Aztlán, to the fascism of New Mexico. Where governments did exist, they were just strong enough to collect the Authority Impost. These little countries were in some ways sovereign. They even fought their little wars—but without the capital industry and high energy

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weapons that made war a threat to the race.

Della doubted that, outside the enclaves, there existed the technical expertise to reproduce the old inventions, much less improve on them. And if someone did discover the secret of the bobble, Authority satellites would detect the construction of the power plants and factories needed to implement the invention.

"I know, I may sound paranoid. But one thing you youngsters don't understand is how technologically stultified the Authoruty is." He glanced at her, as though expecting debate. "We have all the universities and all the big labs. We control most degreed persons on Earth. Nevertheless, we do very little research. I should know, since I can remember my father's lab right before the War—and even more, because I've made sure no really imaginative projects got funded since.

"Our factories can produce most any product that existed before the war." He slapped his hand against the bulkhead. "This is good, reliable craft, probably built in the last five years. But the design is almost sixty years old."

He paused and his tone became less casual. "During the last six months, I've concluded we've made a serious mistake in this. There are people operating under our very noses who have technology substantially in advance of preWar levels."

"I hope you're not thinking of the Mongolian nationalists, sir. I tried to make it clear in my reports that their nuclear weapons were from old Soviet stockpiles. Most weren't usable. And without those bombs they were just pony sol—"

"No, my dear Della, that's not what I am thinking of." He slid a plastic box across the table. "Look inside."

Five small objects sat in the velvet lining. Lu held one in the sunlight. "A bullet?" It looked like an 8mm. She couldn't tell if it had been fired; there was some damage, but no rifling marks. Something dark and glossy stained the nose.

"That's right. But a bullet with a brain. Let me tell you how we came across that little gem.

"Since I became suspicious of these backyard scientists, these Tinkers, I've been trying to infiltrate. It hasn't been easy. In most of North America, we have tolerated no governments. Even though it's cost us on the Impost, the risk of nationalism seemed too high. Now I see that was a mistake. Somehow they've gone further than any of the governed areas—and we have no easy way to watch them, except from orbit.

"Anyway, I sent teams into the ungoverned lands, using whatever cover was appropriate. In Middle California, for instance, it was easiest to pretend they were descendents of the old Soviet invasion force. Their instructions were to hang around in the mountains and ambush any likely-looking travelers. I figured we would gradually accumulate information without any official raids. Last week, one crew ambushed three locals in the forests east of Vandenburg. The quarry had only one gun, a New Mexico 8mm. It was nearly dark, but from a distance of forty meters the enemy hit every one of the ten man crew—with one burst from the 8mm."

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"The New Mexico 8mm only has a ten-round clip. That's—"

"A perfect target score, my dear. And my men swear the weapon was fired on full automatic. If they hadn't been wearing body armor, or if the rounds had had normal velocity, not one of them would have lived to tell the story. Ten armed men killed by one man and a handmade gun. Magic. And you're holding a piece of that magic. Others have been through every test and dissection the Livermore labs could come up with. You've heard of smart bombs? Sure, your air units in Mongolia used them. Well, Miss Lu, these are smart bullets.

"The round has a video eye up front, connected to a processor as powerful as anything we can pack in a suitcase—and our suitcase version would cost 100,000 monets. Evidently the gun barrel isn't rifled; the round can change attitude in flight to close with its target."

Della rolled the metal marble in her palm. "So it's under the control of the rifleman?"

"Only indirectly, and only at 'launch' time. There must be a processor on the gun that queues the targets, and chooses the firing instant. The processor on the bullet is more than powerful enough to latch the assigned target. Rather interesting, eh?"

Della nodded. She remembered how delicate the attack gear on the A511's had been—and how expensive. They'd needed a steady supply of replacement boards from Beijing. If these things could be made cheaply enough to throw away . . .

Hamilton Avery gave a small smile, apparently satisfied with her reaction. "That's not all. Take a look at the other things in the box."

Della dropped the bullet onto the velvet padding, and picked up a brownish ball. It was slightly sticky on her fingers. There were no markings, no variations in its surface. He raised her eyebrows.

"That is a bug, Della. Not one of your ordinary, audio bugs, but full video—we expect in all directions, at that. Something to do with fourier optics, my pet experts tell me. It can record, or transmit a very short distance. We've guessed all this from x-ray micrographs of the interior. We don't even have equipment that can interface with it!"

"You're sure it's not recording right now?"

"Oh yes. They fried its guts before I took it. The microscopists claim there's not a working junction in there.

"Now I think you see the reason for all the precautions."

Della nodded slowly. The bobble bursts were not the reason; he expected their true enemies already knew all about those. Yes, Avery was being clever—and he was as frightened as his cool personality would ever allow.

They sat silently for about thirty seconds. The chopper made another turn, and the sunlight swept across Della's face. They were flying east over Long Beach toward Anaheim—those were the names in the history books anyway. The street pattern stretched off into gray-orange haze. It gave a false sense of order. The reality was kilometer on kilometer of abandoned, burned-out wilderness. It was hard to believe that this threat could grow in North America. But, after

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the fact, it made sense. If you deny big industry and big research to people, they will look for other ways of getting what they need.

. . . And if they could make these things, maybe they were clever enough to go beyond all the beautiful quantum-mechanical theories and figure a way to burst bobbles.

"You think they've infiltrated the Authority?"

"I'm sure of it. We swept our labs and conference rooms. We found seventeen bugs on the West Coast, two in China, and a few more in Europe. There were no repeaters near the overseas finds, so we think they were unintentional exports. The plague appears to spread from California."

"So they know we're on to them."

"Yes, but little more. They've made some big mistakes and we've had a bit of good luck: We have an informer in the California group. He came to us less than two weeks ago, out of the blue. I think he's legitimate. What he's told us matches our discoveries but goes a good deal further. We're going to run these people to the ground. And do it officially. We haven't made an example of anyone in a long time, not since the Yakima incident.

"Your role in this will be crucial, Della. You are a woman, and outside the Authority the frailer sex is disregarded nowadays."

Not only outside the Authority, thought Della.

"You'll be invisible to the enemy, until it's too late."

"You mean a *field* job?"

"Why, yes, my dear. You've certainly had rougher assignments."

"Yes, but—" *but I was a field* director *in Mongolia*.

Avery put his hand on Della's. "This is no demotion. You'll be responsible only to me. As communications permit, you'll control the California operation. But we need our very best out there on the ground, someone who knows the land and can be given a credible cover." Della had been born and raised in San Francisco. For three generations, her family had been 'furbishers—and Authority plants.

"And there is a very special thing I want done. This may be more important than all the rest of the operation." Avery laid a color picture on the table. The photo was grainy, blown up to near the resolution limit. She saw a group of men standing in front of a barn: northern farmers—except for the black child talking to a tall boy who carried an NM 8mm. She could guess who these were.

"See the guy in the middle—by the one with the soldier frizz."

His face was scarcely more than a blotch, but he looked perfectly ordinary, seventy or eighty years old. Della could walk through a crowd in any North American enclave and see a dozen such.

"We think that's Paul Hoehler." He glanced at his agent. "The name doesn't mean anything to you, does it? Well you won't find it in the history books, but I remember him. Back in Livermore, right before the War. I was just a kid. He was in my father's lab and . . . he's the man who invented the bobble."

Della's attention snapped back to the photo. She knew she had just been let in on one of those secrets that was kept from everyone, which would otherwise die with the last of the old Directors.

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She tried to see something remarkable in the fuzzy features.

"Oh, Schmidt, Kashihara, Bhadra, they got the thing into projectable form. But it was one of Hoehler's bright ideas. The hell of it is, the man wasn't—isn't—even a physicist.

"Anyway, he disappeared right after the War started. Very clever. He didn't wait to do any moral posturing, to give us a chance to put him away. Next to eliminating the national armies, catching him was one of our highest priorities. We never got him. After ten or fifteen years, when we had control of all the remaining labs and reactors, the search for Dr. Hoehler died. But now, after all these years, when we see bobbles being burst, we have rediscovered him. . . . You can see why I'm convinced the 'bobble decay' is not natural."

Avery tapped the picture. "This is the man, Della. In the next weeks, we'll take Peace action against hundreds of people. But it will all be for nothing if you can't nail this one man."

FLASHFORWARD

Allison's wound showed no sign of reopening, and she didn't think there was much internal bleeding. It hurt, but she could walk. She and Quiller set up camp—more a hiding place than a camp, really—about twenty minutes from the crash site.

The fire had put a long plume of reddish smoke into the sky. If there was a sane explanation for all this, that plume would attract Air Force rescue. And if it attracted unfriendlies first, then they were far enough away from the crash to escape. She hoped.

The day passed, warm and beautiful—and untouched by any sign of other human life. Allison found herself impatient and talkative. She had theories: A cabin leak on their last revolution could almost explain things. Hypoxia can sneak up on you before you know it—hadn't it killed three Sov pilots in the early days of space? Hell, it could probably account for all sorts of jumbled memories. Somehow their re-entry sequence had been delayed. They'd ended up in the Australian jungles. . . . No, that wasn't right; not if the problem had really happened on the last rev. Perhaps Madagascar was a possibility. That People's Republic would not exactly welcome them. They would have to stay undercover till Air Force tracking and reconnaissance spotted the crash site. . . . A strike-rescue could come any time now, say with the Air Force covering a vtol Marine landing.

Angus didn't buy it. "There's the dome, Allison. No country on Earth could build something like that without our knowing about it. I swear it's kilometers high." He waved at the second sun that stood in the west. The two suns were difficult to see through the forest cover. But during their hike from the crash site they'd had some better views. When Allison looked directly at the false sun with narrowed eyes, she could see that the disk was a distorted oval—clearly a reflection off some vast curved surface. "I know it's huge, Angus. But it doesn't have to be a physical structure. Maybe it's some sort of inversion layer effect."

"You're only seeing the part that's

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way off the ground, where there's nothing to reflect except sky. If you'd climb one of the taller trees, you'd see that the coastline is perfectly reflected in the dome's base."

"Hmm." She didn't have to climb any trees to believe him. What she couldn't believe was his explanation.

"Face it, Allison. We're nowhere in the world we knew. Yet the tombstone shows we're still on Earth."

The tombstone. So much smaller than the dome, yet so much harder to explain. "You still think it's the future?"

Angus nodded. "Nothing else fits. I don't know how fast something like stone carving wears: I suppose we can't be more than a thousand years ahead." He grinned. "An ordinary, Buck Rogers-like interval."

She smiled back. "I guess that would still be better than *The Last Remake* or *Planet of the Apes*."

"Yeah. I never like it where they kill off all the time travelers but one."

Allison gazed through the forest canopy at the second sun. There had to be some other explanation.

They argued it back and forth for hours, in the end agreeing to give the "rescued from Madagascar" theory twenty-four hours to show success. After that they would hike down to the coast, and then along it till they found some form of humanity.

It was late afternoon when they heard it: a whistling scream that grew abruptly to a roar.

"*Aircraft!*" Allison struggled to her feet.

Angus shook himself, and looked into the sky. Then he was standing too, all but dancing from one foot to the other.

Something dark and arrow-shaped swept over them. "An A511, by God," exulted Angus. "Somehow you were right, Allison!" He hugged her.

There were at least three jets. The air was filled with their sound. And it was a joint operation. They glimpsed the third coming to a hover just three hundred meters away. It was one of the new Sikorsky troop carriers. Only the Marines flew those.

They started down the narrow path toward the nearest of the ships, Allison's gait a limping jog. Suddenly Angus' hand closed on her arm. She spun around, off balance. The pilot was pointing through a large gap in the branches, at the hovering Sikorsky. "*Paisley?*" was all he said.

"*What?*" Then she saw it. The outer third of the wings were covered with an extravagant paisley pattern. In the middle was set a green *phi* or *theta* symbol. It was utterly unlike any military insignia she had ever known.

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The atmosphere of an open chess tournament hadn't changed much in the last hundred years. A visitor from 1948 might wonder at the plush, handmade clothing and the strange haircuts. But the important things—the informality mixed with intense concentration, the wide range of ages, the silence on the floor, the long tables and the rows of players—all would have been instantly recognizable.

Only one important thing had changed, and that might have taken the hypo-

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thetical time traveler a while to notice: The contestants did not play alone. Teams were not allowed, but virtually all serious players had assistance, usually in the form of a gray box sitting by the board or on the floor near their feet. The more conservative players used small keyboards to communicate with their programs. Others seemed unconnected to any aid, but every so often would look off into the distance, lost in concentration. A few of these were players in the old sense, disdaining all programmatic magic.

Wili was the most successful of these atavists. His eyes flickered down the row of boards, trying to decide who were the truly human players and who were the fakes. Beyond the end of the table, the Pacific Ocean was a blue band shining through the open windows of the pavilion.

Wili pulled his attention back to his own game, trying to ignore the crowd of spectators and trying even less successfully to ignore his opponent. Though barely out of a Ruy Lopez opening —that's what Jeremy had called it the other night, anyway —Wili had a good feeling about the game. A strong kingside attack should now be possible, unless his opponent had a complete surprise up her sleeve. This would be his fifth straight win. That accounted for the crowd. He was the only purely human player still undefeated. Wili smiled to himself. This was a totally unexpected by-product of the expedition, but a very pleasant one. He had never been admired for anything (unless his reputation within the Ndelante counted as admirable). It would be a pleasure to show these people how useless their machines really were. For the moment he forgot that every added attention would make it harder for him to fade away when the time came.

Wili considered the board a second more, then pushed his bishop pawn, starting a sequence of events that ought to be unstoppable. He punched his clock, and finally raised his eyes to look at his opponent.

Dark brown eyes looked back at him. The girl—woman; she must have been in her twenties—smiled at Wili as she acknowledged his move. She leaned forward, and raised an i/o band to her temple. Soft black hair spilled across that hand.

Almost ten minutes passed. Some of the spectators began drifting off. Wili just sat, and tried to pretend he was not looking at the girl. She was just over one meter fifty, scarcely taller than he. And she was the most beautiful creature he had ever seen. He could sit this close to her and not have to say anything, not have to make cute conversation. . . . Wili rather wished the game might last forever.

When she finally moved, it was another pawn push. Very strange, very risky. She was definitely a soft player: In the last three days, Wili had played more chess than in the last three months. Almost all of it had been against assisted players. Some were mere servants to their machines. You could trust them never to make a simple mistake, and to take advantage of any you made. Playing them was like fighting a bull, impossible if you attack head on, easy once you identify the weak points. Other players, like Jeremy, were soft, more fallible, but full of intricate surprises.

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Jeremy said his program interacted with his own creativity. He claimed it made him better than either machine or human alone. Wili would only agree that it was better than being the slave of a processor.

This Della Lu, her play was as soft as her skin. Her last move was full of risk, and—he saw now—full of potential. A machine alone could never have proposed it.

Rosas and Jeremy drifted into view behind her. Rosas was not entered in the tournament. Jeremy and his Red Arrow special were doing well, but he had a bye on this round. Jeremy caught his eye; they wanted him outside. Wili felt a flash of irritation.

Finally he decided on the best attack. His knight came out from the third rank, brazen ahead of the pawns. He pushed the clock; several minutes passed. The girl reached for her king . . . and turned it over! She stood, extended her hand across the table to Wili. "A nice game. Thank you very much." She spoke in English, with a faint Bay Area twang.

Wili tried to cover his surprise. She had lost, he was sure of that. But for her to see it this early. . . . She must be almost as clever as he. Wili held her cool hand a moment, then remembered to shake it. He stood and gargled something unintelligible, but it was too late. The spectators closed in with their congratulations. Wili found himself shaking hands all around, and some of those hands were jeweled, belonged to Jonque aristocrats. This was, he was told, the first time in five years an unaided player had made it to the final rounds. Some thought he had a chance of winning it all, and how long had it been since a plain human had been North American champion?

By the time he was out of his circle of admirers, Della Lu had retired in graceful defeat. Anyway, Miguel Rosas and Jeremy Sergeivich were waiting to grab him. "A good win," Miguel said, setting his arm across the boy's shoulder. "I'll bet you'd like to get some fresh air after all that concentration."

Wili agreed ungraciously, and allowed himself to be guided out. At least they managed to avoid the two Peace reporters who were covering the event.

The Fonda la Jolla pavilions were built over one of the most beautiful beaches in Aztlán. Across the bay, two thousand meters away, gray-green vineyards topped the tan and orange cliffs. Wili could follow those cliffs and the surf north and north till they vanished in the haze somewhere near Los Angeles.

They started up the lawn toward the resort's restaurant. Beyond it were the ruins of old La Jolla: There was more stonework than in Pasadena. It was dry and pale, without the hidden life of the Basin. No wonder the Jonque lords had chosen La Jolla for their resort. The place was far from both slums and estates. The lords could meet here in truce, their rivalries ignored. Wili wondered what the Authority had done to persuade them to allow the tournament here, though it was possible that the popularity of the game alone explained it.

"I found Paul's friends, Wili," said Rosas.

"Huh?" He came back to their real problems with an unpleasant lurch. "When do we go?"

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"This evening. After your next game. You've got to lose it."

"*What?*Why?"

"Look," Miguel spoke intensely, "we're risking a lot for you. Give us an excuse to drop this project and *we will.*"

Wili bit his lip. Jeremy followed in silence, and Wili realized that Rosas was right for once. Both of them had put their freedom, maybe even their lives, on the line for him—or was it really for Paul? No matter. Next to bobble research, bioscience was the blackest crime in the Authority's book. And they were mixing in it to get him cured.

Rosas took Wili's silence for the acquiescence it was. "Okay. I said you'll have to lose the next one. Make a big scene about it, something that will give us the excuse to get you outside and away from everyone else." He gave the boy a sidelong chance. "You won't find it too hard to do that, will you?"

"Where is . . . it . . . anyway?" asked Jeremy.

But Rosas just shook his head, and once inside the restaurant there was no chance for further conversation.

Roberto Richardson, the tournament roster said. That was his next opponent, the one he must lose to *This is going to be even harder than I thought.* Wili watched his fat opponent walk across the pavilion toward the game table. Richardson was the most obnoxious of Jonque types, the Anglo. And worse, the pattern of his jacket showed he was from the estates above Pasadena. There were very few Anglos in the nobility of Aztlán. Richardson was as pale as Jeremy Sergeivich and Wili shuddered to think of the compensating nastiness the man must contain. He probably had the worst-treated labor gangs in Pasadena. His type always took it out on the serfs, trying to convince his peers that he was just as much a lord as they.

Most Jonques kept only a single bodyguard in the pavilion. Richardson was surrounded by four.

The big man smiled down at Wili as he put his equipment on the table and attached a scalp connector. He extended a fat white hand, and Wili shook it. "I am told you are a former countryman of mine, from Pasadena, no less." He used the formal "you."

Wili nodded. There was nothing but good fellowship on the other's face, as though their social differences were some historical oddity. "But now I live in Middle California."

"Ah, yes. Well, you could scarcely have developed your talents in Los Angeles, could you, son?" He sat down, and the clock was started. Appropriately, Richardson had white.

The game went fast at first, but Wili felt badgered by the other's chatter. The Jonque was all quite friendly, asking him if he liked Middle California, saying how nice it must be to get away from his "disadvantaged condition" in the Basin. Under other circumstances, Wili would have told the Jonque off—there was probably no danger doing so in the truce area. But Rosas had told him to let the game go at least an hour before making an argument.

It was ten moves into the game before Wili realized how far astray his anger was taking him. He looked at Richardson's queen side opening and saw that the advantage of position was firmly in

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his fat opponent's hands. The conversation had not distracted Richardson in the least. Wili looked over his opponent's shoulder at the pale ocean. On the horizon, undisturbed and far away, an Authority tanker moved slowly north. Nearer, two Aztlán sail freighters headed the other way. He concentrated on their silent, peaceful motion till Richardson's comments were reduced to unintelligible mumbling. Then he looked down at the board and put all his concentration into recovery.

Richardson's talk continued for several moments, then faded away completely. The pale aristocrat eyed Wili with a faintly nonplussed expression, but did not become angry. Wili did not notice. For him, the only evidence of his opponent was in the moves on the game. Even when Miguel and Jeremy came in, even when his previous opponent, Della Lu, stopped by the table, Wili did not notice.

For Wili was in trouble. This was his weakest opening of the tournament, and—psychological warfare aside—this was his strongest opponent. Richardson's play was both hard and soft: He didn't make mistakes and there was imagination in everything he did. Jeremy had said something about Richardson being a strong opponent, one who had a fast machine, superb interactive programs, and the intelligence to use them. That had been several days ago, and Wili had forgotten. He was finding out first-hand now.

The attack matured over the next five moves, a tightening noose about Wili's playing space. The enemy (Wili no longer thought of him by name, or even thought of him as a person) could see many moves into the future, could pursue broad strategy even beyond that. Wili had almost met his match.

Each move took longer and longer as the players lapsed into catatonic evaluation of their fate. Finally, with the endgame in sight, Wili pulled the sharpest finesse of his short career. His enemy was left with two rooks—against Wili's knight, bishop and three well-placed pawns. To win he needed some combinatoric jewel, something as clever as his invention of the previous winter. Only now he had twenty minutes, not twenty weeks.

With every move, the pressure in his head increased. He felt like a runner racing an automobile, or like the John Henry of Naismith's story disks. His naked intelligence was fighting an artificial monster, a machine that analyzed a million combinations in the time he could look at one.

The pain shifted from his temples to his nose and eyes. It was a stinging sensation that brought him out of the depths, into the real world.

Smoke! Richardson had lit an enormous cigar. The tarry smoke drifted across the table into Wili's face.

"*Put that out.*" Wili's voice was flat, the rage barely controlled.

Richardson's eyes widened in innocent surprise. He stubbed out his expensive light. "I'm sorry. I knew Northerners might not be comfortable with this, but you blacks get enough smoke in your eyes." He smiled. Wili half-rose, his hands making fists. Someone pushed him back into his chair. Richardson eyed him with tolerant contempt, as if to say "race will out."

Wili tried to ignore the look, and the

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crowd around the table. He had to win now!

He stared and stared at the board. Done right, he was sure those pawns could march through the enemy's fire. But his time was running out and he couldn't recapture his previous state.

His enemy was making no mistakes; *his* play was as infernally deep as ever.

Three more moves. Wili's pawns were going to die. All of them. The spectators might not see it yet, but Wili did, and so did Richardson.

Wili swallowed, fighting nausea. He reached for his king, to turn it on its side and so resign. Unwillingly, his eyes slid across the board and met Richardson's. "You played a good game, son. The best I've ever seen from an unaided player."

There was no overt mockery in the other's voice, but by now Wili knew better. He lunged across the table, grabbing for Richardson's throat. The guards were fast. Wili found himself suspended above the table, held by a half-dozen not-too-gentle hands. He screamed at Richardson, the Spañolnegro curses expert and obscene.

The Jonque stepped back from the table and motioned his guards to lower Wili to the floor. He caught Rosas' eye and said mildly, "Why don't you take your little Alekhine outside to cool off?"

Rosas nodded. He and Jeremy frog-marched the still struggling loser toward the door. Behind them, Wili heard Richardson trying to convince the directors—with all apparent sincerity—to let Wili continue in the tournament.

* * *

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Moments later, they were outside and shed of gawkers. Wili's feet settled back on the turf and he walked more or less willingly between Rosas and Jeremy.

For the first time in years, for the first time since he lost Uncle Sly, Wili found himself crying. He covered his face with his hands, trying to separate himself from the outside world. There could be no keener humiliation than this.

"Let's take him down past the buses, Jeremy. A little walk will do him good."

"It really was a good game, Wili," said Jeremy. "I told you Richardson's rated Expert. You came close to beating him."

Wili barely heard. "I had that Jonque bastard. *I had him!* When he lit that cigar, I lost all my concentration. I tell you, if he weren't such a monstrous cheat, I'd've wiped him."

They walked thirty meters, and Wili gradually quieted. Then he realized there had been no encouraging reply. He dropped his hands and glared at Jeremy. "Well, don't you think so?"

Jeremy was stricken, honesty fighting with friendship. "Richardson is a Mouth, you're right. He goes after everyone like that; he seems to think it's part of the game. You notice how it hardly affected his concentration? He just checkpoints his program when he gets talking, so he can dump back into his original mental set any time. He never loses a beat."

"And so I should have won." Wili was not going let the other wriggle out of the question.

"Well, uh, Wili, look. You're the best unaided player I've ever seen. You lasted more rounds than any other purely-

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human. But be honest: Didn't you feel something different when you played him? I mean apart from his lip? Wasn't he a little more tricky than the earlier players . . . a little more deadly?"

Wili thought back to the image of John Henry and the steam drill. And he suddenly remembered that Expert was the low end of champion class. He began to see Jeremy's point. "So you really think the machines and scalp connects made a difference?"

Jeremy nodded. It was no more than bookkeeping and memory enhancement, but if it could turn Roberto Richardson into a genius, what would it do for. . . . Wili remembered Paul's faint smile at Wili's disdain for mechanical aids. He remembered the hours Paul himself spent in processor connect. "Can you show me how to use such things, Jeremy? Not just for chess?"

"Sure. It will take a while. We have to tailor the program to the user, and it takes time to learn to interpret a scalp connect. But come next year, you'll beat anything—animal, vegetable, or mineral." He laughed.

"Okay," Rosas said suddenly. "We can talk now."

Wili looked up. They had walked far past the parking lots. They were moving down a dusty road that went north around the bay, to the vineyards. The hotel was lost to sight. It was like waking from a dream suddenly to realize that the game and argument were mere camouflage.

"You did a real good job, Wili. That was exactly the incident we needed, and it happened at just the right time." The sun was about twenty minutes above the horizon, its light already misted. Orange twilight was growing. A puffy fog gathered along the beach like some silent army, preparing for its assault inland.

Wili wiped his face with the back of his arm. "No act."

"Nevertheless, it couldn't have worked out better. I don't think anybody will be surprised if you don't show till morning."

"Great."

The road descended. The only vegetation was scraggly chaparral growing around the foundations and the ruined walls. The fog moved over them, scruffy clots of haze, quite different from an inland fog; these were more like real clouds brought close to earth. The sun shone through the mists. The cliffsides were still visible, turning steadily more gold—a dry color that contrasted with the damp of the air.

As they reached beach level, the sun went behind the dense cloud deck at the horizon and spread into an orange band. The colors faded and the fog became more substantial, more opaque. Only a single star, almost overhead, could penetrate the murk.

The road narrowed. The ocean side was lined with eucalyptus, their branches rattling in the breeze. They passed a large sign that proclaimed that the State's highway—this dirt road—was now passing through Viñas Scripps. Beyond the trees, Wili could see regular rows of vertical stakes. The vines were dim gargoyles on the stakes. They walked steadily higher, but the invading fog kept pace, became even thicker. The surf was loud, even sixty meters above the beach.

"I think we're all alone up here," Jeremy said in a low voice.

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"Of course, without this fog, we'd be clear as Vandenberg to anyone at the hotel."

"That's one reason for doing it tonight."

They passed an occasional wagon, no doubt used to carry grapes up the grade to the winery and the caves beneath. The way widened to the left and split into a separate road. They followed the turn-off and saw an orange glow floating in the darkness. It was an oil lamp hung at the entrance to a wide adobe building. A sign—probably grand and colorful in the day—announced in Spanish and English that this was the central winery of Viñas Scripps and that tours for Gentlemen and their Ladies could be scheduled for the daylight hours. Only empty winery carts were parked in the lot fronting the building.

The three walked almost shyly to the entrance. Rosas tapped on the door. It was opened by a thirtyish Anglo woman. They stepped inside but she said immediately, "Tours during daylight hours only, gentlemen." The last word had a downward inflection; it was clear they were not even minor aristocrats. Wili wondered that she opened the door at all.

Miguel replied that they had left the tournament at Fonda la Jolla while it was still day, and hadn't realized the walk was so long. "We've come all the way from Santa Ynez, in part to see your famous winery and its equipment. . . ."

"From Santa Ynez," the woman repeated, and appeared to commiserate. She seemed younger in the light, but not nearly as pretty as Della Lu. Wili's attention wandered to the posters that covered the foyer walls. They illustrated the various stages of the grape-growing and wine-making processes. "Let me check with my supervisor. He may still be up; in which case, perhaps." She shrugged.

She left them alone. Rosas nodded to Jeremy and Wili. So this was the secret laboratory Paul had discovered. Wili had suspected from the moment the buses pulled into La Jolla. This part of the country was so empty that there hadn't been many possibilities.

Finally a man (the supervisor?) appeared at the door. "Mr. Rosas?" he said in English. "Please come this way." Jeremy and Wili looked at each other. *Mr. Rosas*. Apparently they had passed inspection.

Beyond the door was a wide stairway. By the light of their guide's electric flash, Wili saw that the walls were of natural rock. This was the cave system the winery signs boasted of. They reached the floor and walked across a room filled with enormous wooden casks. An overpowering but not unpleasant yeasty smell filled the cavern. Three young workers nodded to them, but did not speak. The supervisor walked behind one of the casks. The back of the wooden cylinder came silently open, revealing a spiral stair. There was barely enough room on it for Jeremy to stand sideways.

"Sorry about the tight fit," the supervisor said. "We can actually pull the stairs downward, out of the cask, so even a thorough search won't find the entrance." He pushed a button on the wall, and a green glow spread down the shaft. Jeremy gave a start of surprise. "Tailored biolight," the man explained. "The stuff uses the carbon

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dioxide we exhale. Can you imagine what it would do to indoor lighting if we were allowed to market it?" He continued in this vein as they descended, talking about the harmless bioscience inventions that could make so much difference to today's world if only they weren't Banned.

At the bottom, there was another cavern. This one's ceiling was covered with glowing green. It was bright enough to read by, at least where it clumped up, over tables and instrument boards. Everyone looked five weeks dead in the fungal glow. It was very quiet; not even surfsound penetrated the rock. There was no one else in the room.

He led them to a table covered with worn linen sheeting. He patted the table and glanced at Wili. "You're the fellow we've been, uh, hired to help?"

"That's right," said Rosas, when Wili gave only a shrug.

"Well, sit up here and I'll take a look at you."

Wili did so, cautiously. There was no antiseptic smell, no needles. He expected the man to tell him to strip, but no such command was given. The supervisor had neither the arrogant indifference of a slave gang vet, nor the solicitous manner of the doctor Paul had called during the spring.

"First off, I want to know if there are any structural problems. . . . Let me see, I've got my scope around here somewhere." He rummaged in an ancient metal cabinet.

Rosas scowled. "You don't have any assistants?"

"Oh, dear me, no." The other did not look up from his search. "There are only five of us here at a time. Before the War, there were dozens of bioscientists in La Jolla. But when we went underground, things changed. For a while, we planned to start a pharmaceutical house as cover. The Authority hasn't Banned those, you know. But it was just too risky. They would naturally suspect anyone in the drug business.

"So we set up Scripps Vineyards. It's nearly ideal. We can openly ship and receive biologically active materials. And some of our development activities can take place right in our own fields. The location is good, too. We're only five kilometers from Old Five. The beach caves were used for smuggling even before the War, even before the United States. . . . Aha, here it is." He pulled a plastic cylinder into the light. He walked to another cabinet and returned with a metal hoop nearly 150 centimeters across. There was a click as he slid it into the base of the cylinder. It looked a little foolish, like a butterfly hoop without a net.

"Anyway," he continued as he approached Wili, "the disadvantage is that we can only support a very few 'vineyard technicians' at a time. It's a shame. There's so much to learn. There's so much good we could do for the world." He passed the loop around the table and Wili's body. At the same time he watched the display at the foot of the table.

Rosas said, "I'm sure. Just like the good you did with the Plague—" He broke off as the screen came to life. The colors were vivid, glowing with their own light. They seemed more alive than anything else in the green-tinted lab. For a moment it looked like the sort of abstract design that's so easy to generate.

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Then Wili noticed movement and asymmetries. As the supervisor slid the hoop back over Wili's chest, the elliptical shape shrank dramatically, then grew again as the hoop moved by his head. Wili rose to his elbows in surprise, and the image broadened.

"Lie back down. You don't have to be motionless, but let me choose the view angle."

Wili lay back, and felt almost violated. They were seeing a cross-section of his own guts, taken in the plane of the hoop! The supervisor brought it back to Wili's chest. They watched his heart squeezing, *thuddub thuddub*. The bioscientist made an adjustment and the view swelled until the heart filled the display. They could see the blood surge in and out of each chamber. A second display blinked on beside the first, this new one filled with numbers of unknown meaning.

The supervisor continued for ten or fifteen minutes, examining all of Wili's torso. Finally, he removed the hoop and studied the summary data on the displays. "So much for the floor show.

"I won't even have to do a genopsy on you, my boy. It's clear that your problem is one we've cured before." He looked at Rosas, finally responding to the other's hostility. "You object to our price, Mr. Rosas?"

The undersheriff started to answer, but the supervisor waved him quiet. "The price is high. We always need the latest electronic equipment. During the last fifty years, the Authority has allowed you Tinkers to flourish. I daresay, you're far ahead of the Authority's own technology. On the other hand, we few poor people in bioresearch have lived in fear, have had to hide in caves to continue our work. And since the Authority has convinced you that we're monsters, most of you won't even sell to us.

"Nevertheless, we've worked miracles these fifty years, Mr. Rosas. If we'd had your freedom, we'd have worked more than miracles. Earth would be Eden now."

"Or a charnel house," Rosas muttered.

The supervisor nodded, seemed only slightly angered. "You say that even when you need us. The Plagues warped both you and the Authority. If it hadn't been for those strange accidents, how different things would be. In fact, given a free hand, we could have saved people like this boy from ever having been diseased."

"How?" asked Wili.

"Why, with another plague," the other replied lightly, reminding Wili of the "mad scientists" in the old TV shows Irma and Bill watched. To suggest a plague after all the Plagues had done. "Yes, another. You see, your problem was caused by genetic damage to your parents. The most elegant countermeasure would be to tailor a virus that moves through the population, correcting just those genotypes that cause the problem."

Fascination with experiment was clear in his voice. Wili didn't know what to think of his savior, this man of good will who might be more dangerous than the Peace Authority and all the Jonque aristocrats put together.

The supervisor sighed and turned off the display. "And yes, I suppose we are crazier than before, maybe even less

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responsible. After all, we've pinned our whole lives on our beliefs, while the rest of you could drift in the open light without fearing the Authority. . . .

"In any case, there are other ways of curing your disease, and we've known them for decades." He glanced at Rosas. "Safer ways." He walked part way down the corridor to a locker, and glanced at a display by the door. "Looks like we have enough on hand." He filled an ordinary looking glass bottle from the locker and returned. "Don't worry, no plague stuff. This is simply a parasite—I should say a symbiont." He laughed shortly. "In fact, it's a type of yeast. If you take five tablets every day till the bottle's empty, you'll establish a stable culture in your gut. You should notice some improvement within ten days."

He put the jar in Wili's hand. The boy stared. Just "—here, take this and all your problems will be gone by morning—" or in ten days, or whatever. Where was the sacrifice, the pain? Salvation came this fast in dreams alone.

Rosas did not seem impressed. "Very well. Red Arrow and the others will pay as promised: programs and hardware to your specifications for three years." The words were spoken with some effort, and Wili realized just how reluctant a guide Miguel Rosas had been—and how important Paul Naismith's wishes were to the Tinkers.

The supervisor nodded, for the first time cowed by Rosas' hostility, for the first time realizing that the trade would produce no general gratitude or friendship.

Wili jumped down from the table and they started back to the stairs. They had not gone ten steps when Jeremy said, "Sir, you said Eden?" His voice sounded diffident, almost frightened. But still curious. After all, Jeremy was the one who dared the Authority with his self-powered vehicles. Jeremy was the one who always talked of science remaking the world. "You said Eden. What could you do besides cure a few diseases?"

The supervisor seemed to realize there was no mockery in the question. He stopped under a bright patch of ceiling and gestured Jeremy Sergeivich closer. "There are many things, son. But here is one . . . how old do you think I am? How old do you think the others at the winery are?"

Discounting the greenish light that made everyone look dead, Wili tried to guess. The skin was smooth and firm, with just a hint of wrinkles around the eyes. The hair looked natural and full. *He had thought forty before. Now he* would say even younger.

And the others they had seen? About the same. Yet in any normal group of adults, more than half were past fifty. And then Wili remembered that when the supervisor spoke of the War, he talked like an oldster, of time in personal memory. "We" decided this, and "we" did that.

He had been adult at the time of the War. He was as old as Naismith or Kaladze.

Jeremy's jaw sagged, and after a moment he nodded shyly. His question had been answered. The supervisor smiled at the boy. "So you see, Mr. Rosas talks of risks—and they may be as great as he claims. But what's to gain is very great, too." He turned and

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walked the short distance to the stairs door—

—which opened in his face. It was one of the workers from the cask room. "Juan," the man began talking fast, "the place is being deep-probed. There are helicopters circling the fields. Lights everywhere."

16

The supervisor stepped back, and the man came off the spiral stair.

"What! Why didn't you call down? Never mind, I know. Have you powered down all Banned equipment?" The man nodded. "Where is the Boss?"

"She's sticking at the front desk. So are the others. She's going to try to brazen it out."

"Hmm." The supervisor hesitated only a second. "It's really the only thing to do. Our shielding should hold up. They can inspect the cask room all they want." He looked at the three Northerners. "We two are going up and say hello to the forces of worldwide law and order. If they ask, we'll tell them you've already departed along the beach route."

Wili's cure might still be safe.

The supervisor made some quick adjustment at a wall panel. The fungus gradually dimmed, leaving a single streak that wobbled off into the dark. "Follow the glow and you'll eventually reach the beach. Mr. Rosas, I hope you understand the risk we take in letting you go. If we survive, I expect you to make good on our bargain."

Rosas nodded, then awkwardly accepted the other's flashlight. He turned and hustled Jeremy and Wili off into the dark. Behind them, Wili heard the two bioscientists climbing the stairs to their own fate.

The dim band turned twice, and the corridor became barely shoulder wide. The stone was moist and irregular under Wili's hand. The tunnel went downhill now and was deathly dark. Miguel flicked on his light and urged them to a near run. "Do you know what the Authority will do to a lab—even a suspected one?"

Jeremy was hot on Wili's heels, occasionally bumping into the smaller boy, though never quite hard enough to make them lose their balance. What would the Authority do? Wili's answer was half a pant. "Bobble it?"

Of course. Why risk a conventional raid? If they even had strong suspicions, the safest action would be to embobble the whole place, killing the scientists and isolating whatever death seed might be stored here. Even without the Authority's reputation of harsh punishment for Banned research, it made complete sense. Any second now, they might find themselves inside a vast silver sphere. Inside.

Dio, perhaps it had happened already. Wili half-stumbled at the thought, nearly losing his grip on the glass jar that was the reason for the whole adventure. They would not know till they ran headlong into the wall. They would live for hours, maybe days, but when the air gave out they would die as all the thousands before them must have died, at Vandenberg and Point Loma and Huachuca and . . .

The ceiling came lower, till it was barely centimeters above Wili's head. Jeremy and Miguel pounded clumsily

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along, bent over yet trying to run at full speed. Light and shadow danced jaggedly about them.

Wili watched ahead for three figures running toward them: The first sign of embobblement would be their own reflections ahead of them. And there *was* something moving up there. Close.

"Wait! Wait!" he screamed. The three came to an untidy stop before—a door, an almost ordinary door. Its surface was metallic, and that accounted for the reflection. He pushed the opener. It swung outward, and they could hear the surf. Miguel doused the light.

They started down a stairs, but too fast. Wili heard someone trip and an instant later he was hit from behind. The three tumbled down the steps. Stone bit savagely into his arms and back. Wili's fingers spasmed open and the jar flew into space, its landing marked by the sound of breaking glass.

Life's blood spattering down unseen steps.

He felt Jeremy scramble past him. "Your flashlight, Miguel, quick."

After a second, light filled the stairs. If any Peace cops were on the beach looking inward . . .

It was a risk they took for him.

Wili and Jeremy scrabbled back and forth across the stairs, unmindful of the glass shards. In seconds they had recovered the tablets—along with considerable dirt and glass. They dumped it in Jeremy's waterproof hiking bag. The boy dropped a piece of paper into the bag. "Directions, I bet." He zipped it shut and handed it to Wili.

Rosas kept the light on a second longer, and the three memorized the path they must follow. The steps were scarcely more than water-worn corrugations. The cave was free of any other human touch.

Darkness again, and the three started carefully downwards, still moving faster than was really comfortable. If only they had a night scope. Such equipment wasn't Banned, but the Tinkers didn't flaunt it. The only high tech equipment they'd brought to La Jolla was the Red Arrow chess processor.

Wili thought he saw light ahead. Over the surf drone he heard a *thupthupthup* that grew first louder and then faded. A helicopter.

They made a final turn and saw the outside world through the vertical crack that was the entrance to the cave. The evening mist curled in, not as thick as earlier. A horizontal band of pale gray hung at eye level. After a moment, he realized the glow was thirty or forty meters away—the surf line. Every few seconds, something bright reflected off the surf and waters beyond.

Behind him Rosas whispered, "Light splash from their search beams on top of the bluff. We may be in luck." He pushed past Jeremy and led them to the opening. They hid there a few seconds, and looked as far as they could up and down the beach. No one was visible, though there were a number of aircraft circling the area. Below the entrance spread a rubble of large boulders, big enough to hide their progress.

It happened just as they stepped away from the entrance: A deep, bell-like tone was followed by the cracking and crashing of rock now free of its parent strata. The avalanche proceeded all around them, thousands of tons of rock adding itself to the natural debris of the coast-

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line. They cowered beneath the noise, waiting to be crushed.

But nothing fell close by, and when Wili finally looked up, he saw why. Silhouetted against the mist and occasional stars was the perfect curve of a sphere. The bobble must be two or three hundred meters across, extending from the lowest of the winery's caves to well over the top of the bluff and from the inland vineyards to just beyond the edge of the cliffs.

"They did it. They really did it," Rosas muttered to himself.

Wili almost shouted with relief. A few centimeters the other way and they would have been entombed.

Jeremy!

Wili ran to the edge of the sphere. The other boy had been standing right behind them, but surely close enough to be safe. Then where was he? Wili beat his fists against the blood warm surface. Rosas' hand closed over his mouth and he felt himself lifted off the ground. Wili struggled for a moment in enforced silence, then went limp. Rosas set him down.

"I know," Miguel's voice was a strangled whisper. "He must be on the other side. But let's make sure." He flicked on his light—almost as brightly as he had risked in the cave—and they walked several meters back and forth along the line where the bobble passed into the rocks. They did not find Jeremy, but—

Rosas' flash stopped for a moment, freezing one tiny patch of ground in its light. Then the light winked out, but not before Wili saw two tiny spots of red, two . . . fingertips . . . lying in the dirt.

Just centimeters away, Jeremy must lie writhing in pain, staring into the darkness, feeling the blood on his hands. The wound could not be fatal. Instead, the boy would have hours still to die. Perhaps he would return to the labs, and sit with the others—waiting for the air to run out. The ultimate excommunication.

"You have the bag?" Rosas' voice quavered.

The question caught Wili as he was reaching for the mangled fingers. He stopped, straightened. "Yes."

"Well then, let's go." The words were curt, the tone was clamped-down hysteria.

The undersheriff grabbed Wili's shoulder and urged him down the jumble of half-seen rocks. The air was filled with dust and the cold moistness of the fog. The fresh broken rock was already wet and slippery. They clung close to the largest boulders, fearing both landslides and detection from the air. The bobble and bluffs cut a black edge into the hazy aura of the lights that swept the ground above. They could hear both trucks and aircraft up there.

But no one was down on the beach. As they crawled and climbed across the rocks, Wili wondered at this. Could it be the Authority did not know about the caves?

They didn't speak for a long time. Rosas was leading them slowly back toward the hotel. It might work. They could finish the tournament, get on the buses, and return to Middle California as though nothing had happened. As though Jeremy had never existed.

It took nearly two hours to reach the beach below the hotel. The fog was

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much thinner now. The tide had advanced; phosphorescent surf pounded close by, surging tendrils of foam to near their feet.

The hotel was brightly lit, more than he remembered on previous evenings. There were lots of lights in the parking areas, too. They hunkered down between two large rocks and inspected the scene. There were far too many lights. The parking lots were swarming with vehicles and men in Peacer green. To one side stood a ragged formation of civilians—prisoners? They stood in the glare of the trucks' lights, with their hands clasped on top of their heads. A steady procession of soldiers brought boxes and displays—the chess-assist equipment—from the hotel. It was much too far away to see faces, but Wili thought he recognized Roberto Richardson's fat form and flashy jacket there among the prisoners. He felt a quick thrill to see the Jonque standing like some recaptured slave.

"They raided everybody . . . just like Paul said, they finally decided to clean us all out." Anger was back in Miguel's voice.

Where was the girl, Della Lu? He looked back and forth over the forlorn group of prisoners. She was so short. Either she was standing in back, or she was not there. Some of the buses were leaving. Maybe she had already been taken.

They had had amazing luck avoiding the bobble, avoiding detection, and avoiding the hotel raid. That luck must end now: They had lost Jeremy. They had lost the equipment at the hotel. Aztlán territory extended northward three hundred kilometers. They would have to walk more than a hundred klicks through wilderness just to reach the Basin. Even if the Authority was not looking for them, they could not avoid the Jonque barons, who would take Wili for a runaway slave—and Rosas for a peasant till they heard him talk, and then for a spy.

And if by some miracle they could reach Middle California, what then? This last was the most depressing thought of all. Paul Naismith had often talked of what would happen when the Authority finally saw the Tinkers as enemies. Apparently that time had come. All across the continent (all across the world? Wili remembered that some of the best chip engraving was done in France and China) the Authority would be cracking down. The Kaladze farm might even now be a smoking ruin, its people lined up with hands on heads, waiting to be shipped off to oblivion. And Paul would be one of them—if he wasn't already dead.

They sat in the cleft of the boulders for a long time, moving only to stay ahead of the tide. The sounds of soldiers and vehicles diminished. One by one the search lights went out. One by one the buses rolled away—what had seemed marvelous carriages of speed and comfort just a few days before, now cattle cars.

If the idiots didn't search the beach, he and Rosas might have to walk north after all.

It must have been about three in the morning. The surf was just past its highest advance. There were still troopers on the hill near the hotel, but they didn't seem especially vigilant. Rosas was be-

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ginning to talk about starting north while it was still dark.

They heard a regular, scritching sound on the rocks just a few meters away. The two fugitives peeked out of their hiding place. Someone was pushing a small boat into the water, trying to get it past the surf.

"I think that girl could use some help," Miguel remarked.

Wili looked closer. It was a girl, wet and bedraggled, but familiar: Della Lu had not been captured after all!

17

Paul Naismith was grateful that even in these normally placid times there were still a few paranoids around—in addition to himself, that is. In some ways, Kolya Kaladze was an even worse case than he. The old Russian had devoted a significant fraction of his "farm's" budget to constructing a marvelous system of secret passages, hidden paths, small arms caches and redoubts. Naismith had been able to travel more than ten kilometers from the farm, all the way around the Salsipuedes, without ever being exposed to the sky—or the unwelcome visitors that lurked about the farm.

Now well into the hills, he felt relatively safe. There was little doubt the Authority had observed the same event he had. Sooner or later they would divert resources from their various emergencies and come investigate the peculiar red smoke plume. Paul hoped to be long gone before that happened. In the meantime, he would take advantage of this incredible good luck. Revenge had waited, impotent, these fifty years, but its time might now come.

Naismith geed the horse. The cart and horse were not what he had come to the farm with. Kolya had supplied everything—including a silly, old-lady disguise which he suspected was more embarrassing than effective.

Nikolai had not stinted, but neither had he been happy about the departure. Naismith slouched back on the padded seat and thought ruefully of that last argument. They had been sitting on the verandah of the main house. The blinds were drawn, and a tiny singing vibration in the air told Naismith that the window panes were incapable of responding to a laser-driven audio probe. The Peace Authority "bandits" (what an appropriate cover) had made no move. Except for what was coming over the radio, and what Paul had seen, there was no sign that the world was turning upside down.

Kaladze understood the situation—or thought he did—and wanted no part of Naismith's project. "I tell you honestly, Paul, I do not understand you. We are relatively safe here. No matter what the Peacers say, they can't act against us all at once; that's why they grabbed our friends at the tournament. For hostages." He paused, probably thinking of a certain three of those hostages. Just now, they had no way of knowing if Jeremy and Wili and Miguel were dead or alive, captive or free. Taking hostages might turn out to be an effective strategy indeed. "If we keep our heads down, there's no special reason to believe they'll invade Red Arrow Farm. You'll be as safe here as anywhere. *But,*" Kolya rushed on as if to forestall an immediate response, "if you leave

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now, you'll be alone and in the open. You want to head for one of the few spots in North America where the Peacers are guaranteed to swarm. For which risk, you get *nothing*."

"You are three times wrong, old friend," Paul answered quietly, barely able to suppress his frantic impatience to be gone. He ticked off the points. "To your second claim: If I leave right now, I can probably get there before the Authority. They have much else to worry about. Since we got Wili's invention working, I and my programs have spent every second monitoring the Peacer recon satellites for evidence of bobble decay. I'll bet the Authority itself doesn't have the monitor capability I do. It's possible they don't yet realize that a bobble burst up there in the hills this morning.

"As to your third claim: The risk *is* worth the candle. I stand to win the greatest prize of all, the means to destroy the Authority. Something or someone is causing bobbles to burst. So there is some defense against the bobbles. If I can discover that secret—"

Kaladze shrugged. "So? You'd still need a nuclear power generator to do anything with the knowledge."

"Maybe. . . . Finally, my response to your first claim: You—we—are not at all safe lying low on the farm. For years, I tried to convince you the Authority is deadly once it sees you as a danger. You're right, they can't attack everywhere at once. But they'll use the La Jolla hostages to identify you, and to draw you out. Even if they don't have Miguel and the boys, Red Arrow Farm will be high on their hit list. And if they suspect I'm here, they'll raid you just as soon as they have enough force in the area. They have some reason to fear me."

"They want *you*?" Kaladze's jaw sagged. "Then why haven't they simply bobbled us?"

Paul grinned. "Most likely, their 'bandit' reconnaissance didn't recognized me—or maybe they want to be sure I'm inside their cage when they lock it." *Avery missed me once before. He can't stand uncertainty.*

"Bottom line, Kolya: The Peace Authority is out to get us. We must give them the best fight we can. Finding out what's bursting the bobbles might give us the whole game." No need to tell Kolya that he would do it even if the Peacers hadn't raided the tournament. Like most Tinkers, Nikolai Kaladze had never been in direct conflict with the Authority. Though he was as old as Naismith, he had not seen firsthand the betrayal that had brought the Authority to power. Even the denial of bioproducts to children like Wili was not seen by today's people as real tyranny. But now at last there was the technical and—if the Authority was foolish enough to keep up its pressure on the likes of Kaladze—the political opportunity to overturn the Peacers.

The argument continued for thirty minutes, with Naismith slowly prevailing. The real problem in getting Kolya's help was to convince him that Paul had a chance of discovering anything from a simple inspection of this latest bobble burst. In the end, Naismith was successful, though he had to reveal a few secrets out of his past that might later cause him considerable trouble.

* * *

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The path Naismith followed leveled briefly as it passed over a ridgeline. If it weren't for the forest, he could see the crater from here. He had to stop daydreaming and decide just how to make his approach. There was still no sign of Peacers, but if he were picked up near the site, the old-lady disguise would be no protection.

He guided his horse off the path some thousand meters inland of the crater. Fifty meters into the brush, he got down from the cart. Under ordinary circumstances there was more than enough cover to hide horse and vehicle. Today, and here, he couldn't be so confident.

It was a chance he must take. For fifty years, bobbles—and the one up ahead, in particular—had haunted him. For fifty years he had tried to convince himself that all this was not his fault. For fifty years he had hoped for some way to undo what his old bosses had made of his invention.

He took his pack off the cart and awkwardly slipped it on. The rest of the way would be on foot. Naismith trudged grimly back up the forested hillside, wondering how long it would be before the pack harness began to cut, wondering if he would run out of breath first. What was just a casual walk for a sixty-year-old might be life-threatening for someone his age. He tried to ignore the creaking of his trick knee and the rasping of his breath.

Aircraft. The sound passed over, but did not fade into the distance. Another and another. Damn it.

Naismith took out some gear, and began monitoring the remotes that Jeremy had scattered the night of the ambush. He was still three thousand meters from the crater, but some of the pellets might be in enough sun to be charged up and transmitting.

He searched methodically through the entire packet space his probes could transmit on. The ones nearest the crater were gone or so deeply embedded in the forest floor that all he could see was the sky above them. There had been a fire, maybe even a small explosion, when this bobble burst. But no ordinary fire could have burned within the bobble for fifty years. If a nuclear explosion had been trapped inside, there would have been something much more spectacular than a fire when it burst. (And Naismith knew this one: there had been no nuke in it.) That was the unique thing about this bobble burst; it might explain the whole mystery.

He had fragmentary views of uniforms. Peacer troops. They had left their aircraft and were spreading around the crater. Naismith piped the audio to his hearing aid. He was so close. But it would be crazy to go any nearer now. Maybe if they didn't leave too many troops, he could sneak in tomorrow morning. He had arrived too late to scoop them and too early to avoid them. Naismith swore softly to himself, and unwrapped the lightweight camping bag Kaladze had given him. All the time, he watched the tiny screen he had propped against a nearby tree trunk. The controlling program shifted the scene between the five best views he had discovered in his initial survey. It would also alert him if anyone started moving in his direction.

Naismith settled back, and tried to relax. He could hear lots of activity but

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it must be right down in the crater, since he could see none of it.

The sun slowly drifted west. Another time, Naismith would have admired the beautiful day: temperatures in the high twenties, birds singing. The strange forests around Vandenberg might be unique: dry climate vegetation suddenly plunged into something resembling the rainy tropics. God only knew what the climax forms would be like.

Today, all he could think of was getting at that crater just a few thousand meters to the north.

Even so, he was almost dozing when a distant rifle shot brought him to full alertness. He diddled the display a moment, and had some good luck: He saw a man in gray and silver, running almost directly away from the camera. Naismith strained close to the screen, his jaw sagging. More shots. He zoomed on the figure. Silver. He hadn't seen an outfit like that since before the War. For a moment his mind offered no interpretation, just cranked on as a stunned observer. Three troopers rushed past the camera. They must have been shooting over the fellow's head, but he wasn't stopping and now the trio fired again. The man in gray spun and dropped. For a moment, the three soldiers seemed as stricken as their target. Then they ran forward, shouting recriminations at each other.

The screen was alive with uniforms. There was a sudden silence at the arrival of a tweedy civilian. The man in charge. From his high-pitched expostulations, Naismith guessed he was unhappy with events. A stretcher was brought up and the still form was carted off. Naismith changed the phase of his camera and followed the victim down the path that led northwards from the crater.

Minutes later the shriek of turbines splashed off the hills, and a needle-nosed form rose into the sky north of Naismith. The craft vectored into horizontal mode and sprinted southward, passing low over Naismith's hiding place.

The birds and insects were deathly silent the next several minutes, almost as silent and awestruck as Paul's own imagination. *He knew now*. The bursting bobbles were not caused by quantum decay. The bursting bobbles were not the work of some anti-Peacer underground. He fought down hysterical laughter. He had invented the damn things, provided his bosses with fifty years of empire, but he and they had never realized that—though his invention worked superbly—his theory was a crock of sewage from beginning to end.

He knew that now. The Peacers would know it in a matter of hours, if they had not already guessed. They would fly in a whole division with their science teams. He would likely die with his secret if he didn't slip out now and head eastward for his mountain home.

. . . But when Naismith finally moved, it was not back to his horse. He went north. Carefully, quietly, he moved toward the crater: for there was a corollary to his discovery, and it was more important than his life, perhaps even more important than his hatred of the Peace Authority.

18

Naismith stopped often, both to rest

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and to consult the screen that he had strapped to his forearm. The scattered cameras showed fewer than thirty troopers. If he had guessed their location correctly, he might be able to crawl in quite close. He made a two hundred meter detour just to avoid one of them; the fellow was well concealed, and was quietly listening and watching. Naismith suffered the rocks and brambles with equal silence. He carefully inspected the ground just ahead of him for branches and other noise-makers. Every move must be a considered one. This was something he had very little practice at, but he had to do it right the first time.

He was very close to his goal now: Naismith looked up from the display and peered into a small ravine. This was the place! Her suddenly still form huddled deep within the brush. If he hadn't known from the scanners exactly where to look, he would not have noticed the flecks of silver beyond the leaves and branches. During the last half hour he had watched her move slowly south, trying to edge away from the troopers at the crater's rim. Another fifteen minutes, and she would blunder into the soldier Naismith had noticed.

He slid down the cleft, through clouds of midges that swirled in the musty dampness. He was sure she could see him now. But he was obviously no soldier, and he was crawling along just as cautiously as she. Paul lost sight of her the last three of four meters of his approach. He didn't look for her; instead he eased into the depths of shadow that drowned her hiding place.

Suddenly a hand slammed over his mouth and he found himself spun onto his back and forced to the ground. He looked up into a pair of startlingly blue eyes.

The young woman waited to see if Naismith would struggle, then released his shoulder and placed her finger to her lips. Naismith nodded, and after a second she removed her hand from his mouth. She lowered her head to his ear and whispered, "Who are you? Do you know how to get away from Them?"

Naismith realized with wry bleakness that she had not seen through his disguise: she thought she'd landed some dazed crone. Perhaps that was best. He had no idea what she imagined was going on, but it could hardly be any approximation to reality. There was no truthful answer she would understand, much less believe. Naismith licked his lips in apparent nervousness and whispered back, "They're after me, too. If they catch us they'll kill us, just like your friend." *Oops.* "We've got to turn from the way you're going. I saw one of 'em hiding just ahead."

The young woman frowned, her suspicion clear. Naismith's omniscience was showing. "So you know a way out?"

He nodded. "My horse and wagon are southeast of all this ruckus. I know ways we can sneak past these folks. I have a little farm up in—"

His words were lost in a steadily increasing roar that passed almost overhead. They looked up and had a quick impression of something large and winged, fire glowing from ports at wings and tail. Another troop carrier. He could hear others following. This was the beginning of the real invasion. The only place they could land would be on the main road north of the crater.

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But given another half hour, there would be wall to wall troopers here and not even a mouse could escape.

Naismith rolled to his knees and pulled at her hand. She had no choice now. They stood and walked quickly back the way he had come. The sound of the jets was a continuous rumble; they could have shouted and still not been heard. They had perhaps fifteen minutes to move as fast as they were able.

Greenish twilight had fallen on the forest floor. In his mottled brown dress, Naismith would be hard to spot, but the girl's flight fatigues made her a perfect target. He held her hand, urging her to paths he thought safe. He glanced at his wrist again and again, trying to see where the invaders were posted. The girl was busy looking in all directions, and didn't notice his display.

The sounds fell behind them. The jets were still loud, but the soldiers' voices were doll-like in the distance. A dove lilted nearby.

They were trotting now, where the undergrowth thinned. Naismith's lungs burned and a steady pain pushed in his chest. The woman had a limp, but her breath came effortlessly. No doubt she had to slow her pace to his.

Finally he was forced to a stumbling walk. She put her arm around his shoulder to keep him steady. Naismith grimaced but did not complain. He should be grateful that he could even walk, he supposed. But somehow it seemed a great injustice that a short run could be nearly fatal to someone who still felt young inside. He croaked directions, telling the girl where the horse and cart were hidden.

Ten minutes more, and he heard a faint nickering. There was no sign of an ambush. From here, he knew dozens of trails into the mountains, trails that guerrillas of bygone years had worked hard to conceal. With even a small amount of further luck, they could escape. Paul sagged against the side of the cart. The forest rippled and darkened before him. Not now, Lord, *not now!*

His vision cleared, but he didn't have the strength to hoist himself onto the cart. The young woman's arm slipped to his waist, while her other went under his legs. Paul was a little taller than she, but he didn't weigh much anymore, and she was strong. She lifted him easily into the back, then almost dropped him in surprise. "You're not a—"

Naismith gave her a weak grin. "A woman? You're right. In fact, Allison, there's scarcely a thing you've seen today that is what it seems." Her eyes widened even further, and her face went pale. *How does he know my name?* was obvious in her stare.

But Paul was almost beyond speech. He pointed her at one of the hidden paths. It should get them safely away, if she could follow it.

And then the world darkened and fell away from him.

19

The ocean was placid today, but the fishing boat was small. Della Lu stood at the railing and looked down into the sun-sparkled water with a sick fascination. In all the Peace, she had as much counter-subversive experience as anyone. In a sense her experience had begun as soon as she was old enough to understand her parents' true job. And

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as an adult, she had planned and participated in airborne assaults, had directed the embobbling of three Mongolian strongholds, had been as tough as her vision of the Peace demanded . . . but until now she had never been in a watercraft bigger than a canoe.

Was it possible she could be seasick? Every three seconds, the swell rose to within a couple meters of her face, then sank back to reveal scum-covered timbers below the waterline. It had been vaguely pleasant at first, but one thing she'd learned during the last thirty-six hours was that *it never ended*. She had no doubt she would feel fine just knowing the motion could be stopped at her whim. But short of calling off this charade, there was no way to get away from it.

Della ordered her guts to sleep, and her nose to ignore the stench of sardines. She looked up from the waterline to the horizon. She really had a lot to be proud of. In North America—and in Middle California, especially—the Authority's espionage service was an abomination. There had been no threats from this region in many, many years. The Peace kept most of the continent in a state of anarchy. Their satellite reconnaissance could spot the smallest agglomeration of power there. Only in the nation states, like Aztlán and New Mexico, did the Directors see any need for spies. Things were very different in the great land ocean that was Central Asia.

But Della was managing. In a matter of days, she had improvised from her Asian experience to come up with something that might work against the threat Avery saw here. She had not simply copied her Mongolian procedures. In North America, the subersives had penetrated—at least in an electronic sense—some of the Authority secrets. Communications, for instance: Della's eyes caught on the Authority freighter near the horizon. She could not report directly from her little fishing boat without risking her cover. So she had a laser installed near the waterline, and with it talked to the freighter—which surcrypted the messages and sent them through normal Authority channels to Hamilton Avery and the operations that Della was directing for him.

Laughter. One of the fisherman said something in Spanish, something about "persons much inclined to sleep." Miguel Rosas had climbed out of the boat's tiny cabin. He smiled wanly at their jokes as he picked his way past the nets. (Those fishermen were a weak point in her cover. They were real, hired for the job. Given time, they would likely figure out whom they were working for. The Authority should have a whole cadre of professionals for jobs like this. Hell, that had been the original purpose in planting her grandparents in San Francisco: The Authority had been worried about the large port so close to the most important enclave. They reasoned that 'furbishers would be the most likely to notice any build-up of military materiel. If only they had chosen to plant them among Tinkers instead. As it was, the years passed and no threat developed, and the Authority never expanded their counter-underground.)

Della smiled at him, but didn't speak till the Californian was standing beside her. "How is the boy?"

Rosas frowned. "Still sleeping. I

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hope he's okay. He's not in good health, you know."

Della was not worried. She had doctored the black kid's bread, what the fishermen fed him last night. It wouldn't do the boy any harm, but he should sleep for several more hours. It was important that she and Rosas have a private conversation, and this might be the last natural opportunity for it.

She looked up at him, keeping her expression innocent and friendly. *He doesn't look weak. He doesn't look like a man who would betray his people . . .* And yet he had. So his motives were very important if they were to manipulate him further. Finally she said, "We want to thank you for uncovering the lab in La Jolla."

The undersheriff's face went rigid, and he straightened.

Lu cocked her head quizzically. "You mean you didn't guess who I am?"

Rosas slumped back against the railing, looked dully over the side. "I suspected. It was all too pat: our escape, these fellows picking us up. I didn't think you'd be a woman, though. That's so old-fashioned." His dark hands clenched the wood till the knuckles shone pale. "Damn it, lady, you and your men killed Jere—killed one of the two I was here to protect. And then you grabbed all those innocent people at the tournament. *Why?* Have you gone crazy?"

The man hadn't guessed that the tournament raid was the heart of Avery's operation; the biolab had been secondary, important mainly because it had brought Miguel Rosas to them. They needed hostages, information.

"I'm sorry our attack on the lab killed one of your people, Mr. Rosas. That wasn't our intent." This was true, though it might give her a welcome leverage of guilt. "You could have simply told us its location, not insisted on a 'Judas kiss' identification. You must realize, we couldn't take any chance that what was in the lab might get out. . . ."

Rosas was nodding, almost to himself. *That must be it.* The man had a pathological hatred of bioscience, far beyond the average person's simple fear. That was what had driven him to betrayal. "As for the raid on the tournament, we had very good reasons for that, reasons which you will someday understand and support. For now you must trust us, just as the whole world has trusted us these last fifty years, and follow our direction."

"Direction? The hell you say. I did what I had to do, but that's the end to my cooperation. You can lock me up like the rest."

"I think not. Your safe return to Middle California is a high priority with us. You and I and Wili will put ashore at Santa Barbara. From there we should be able to get to Red Arrow Farm. We'll be heroes, the only survivors of the infamous La Jolla raid." She saw the defiance on his face. "You really have no choice, Miguel Rosas. You have betrayed your friends, your employers, and all the people we arrested at the tournament. If you don't go along, we will let it be known you were behind the raids, that you have been our agent for years."

"That's a damn lie!" His outburst was clipped short as he realized its irrelevance.

"On the other hand, if you do help

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us . . . well, then you will be serving a great good—'' Rosas did not sneer, but clearly he did not believe it either — ''and when all this is over you will be very rich, if necessary protected by the Peace for the rest of your life.'' It was a strategy that had worked on many, and not just during the history of the Peace: take a weak person, encourage him to betrayal (for whatever reason) and then use the stick of exposure and the carrot of wealth to force him to do far more than he'd ever have had the courage or motive for in the beginning. Hamilton Avery was confident it would work here, and had refused her time for anything more subtle. Miguel Rosas might get them a line on the Hoehler fellow.

Della watched him carefully, trying to pierce his tense expression and see whether he was strong enough to sacrifice himself.

The undersheriff stared at the gulls that circled the boat, calling raucously to their brethren as the first catch was drawn aboard. For a moment he seemed lost in the swirl of wings, and his jaw muscles slowly relaxed.

Finally he looked back at her. ''You must be very good at chess. I can't believe the Authority has chess programs that could play the way you did Wili.''

Della almost laughed at the irrelevance of the statement, but she answered honestly. ''You're right; they don't. But I scarcely know the moves. What you all thought was my computer was actually a phone link to Livermore. We had our hottest players up there going over my game, figuring out the best moves and then sending them down to me.''

Now Rosas did laugh. His hand came down on her shoulder. She almost struck back before she realized this was a pat and not a blow. ''I had wondered. I had really wondered.

''Lady, I hate your guts, and after today I hate everything you stand for. But you have my soul now.'' The laughter was gone from his voice. ''What are you going to make me do?''

No, Miguel, I don't have your soul, and I see that I never will. Della was suddenly afraid—for no reason that could ever convince Hamilton Avery —that Miguel Rosas was not their tool. Certainly, he was naive; outside of Aztlán and New Mexico, most North Americans were. But whatever weakness caused him to betray the Scripps lab ended there. And somehow she knew that whatever decision he had just made could not be changed by gradually forcing him to more and more treacherous acts. There was something very strong in Rosas. Even after his act of betrayal, those who counted him friend might still be lucky to know him.

''To do? Not a great deal. Sometime tonight we reach Santa Barbara. I want you to take me along when we put ashore. When we reach Middle California, you'll back up my story. I want to see the Tinkers first hand.'' She paused. ''There is one thing. Of all the subversives, there is one most dangerous to world peace. That man used to be called Paul Hoehler.'' Rosas did not react. ''We've seen him at Red Arrow Farm. We want to know what he's doing. We want to know where he is.''

That had become the whole point of the operation for Hamilton Avery. The Director had an abiding paranoia about

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Hoehler. He was convinced that the bursting bobbles were not a natural phenomenon, that someone in Middle California was responsible. Up till yesterday, she had considered it all dangerous fantasy, distorting their strategy, obscuring the long-term threat of Tinker science. Now she was not so sure. Last night, Avery called to tell her about the spacecraft the Peace had discovered in the hills east of Vandenberg. The crash was only hours old and reports were still fragmentary, but it was clear that the enemy had a manned space operation. If they could do that in secret, then almost anything was possible. This was a time for greater ruthlessness than ever she had needed in Mongolia.

Above and around, the gulls swooped through the chill blue glare, circling closer and closer as the fish piled up at the rear of the boat. Rosas' gaze was lost among the scavengers. Della, for all her skill, could not tell whether she had a forced ally or a double traitor. For both their sakes she hoped he was the former.

20

Parties and fairs were common among the West Coast Tinkers. Sometimes it was difficult to tell one from the other, so large were the parties and so informal the fairs. As a child, the high points of Rosas's existence had been such events: tables laden with food, kids and oldsters come from kilometers around to enjoy each other's company in the bright outdoors of sunny days or crowded into warm and happy dining rooms while rain swept by outside.

The La Jolla crackdown had changed much of that. Rosas strained to appear attentive as he listened to a Kaladze niece marvel at their escape and long trek back to Middle California. His mind roamed grim and nervous across the scene of their welcome-home party. Only Kaladze's family attended. There was no one from other farms or from Santa Ynez; even Seymour Wentz had not come. The Peacers were not to suspect that anything special was happening at Red Arrow Farm.

But Sy was not totally missing. He and some of the neighbors had shown up on line-of-sight holos from their homes inland. Sometime this evening they would have a council of war.

I wonder if I can face Sy and not give away what really happened in La Jolla?

Wilma Wentz—Kaladze's niece and Sy's sister-in-law, a woman in her late forties—was struggling to be heard over music that came from a speaker hidden in a nearby tree. "But I still don't understand how you managed once you reached Santa Barbara. You and a black boy and an Asian woman traveling together. We know the Authority had asked Aztlán to stop you. How did you get past the border?"

Rosas wished his face were in shadows, not lit by the pale glow bulbs that were strung between the trees. Wilma was only a woman, but she was clever and more than once had caught him out when he was a child. He must be as careful with her as anyone. He laughed. "It was simple, Wilma—once Della suggested it: We stuck our heads right back into the lion's mouth. We found a Peacer fuel station and climbed into the undercarriage of one of the tankers. No Aztlán cop stops one of those. We

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had a nonstop ride from there to the station south of Santa Ynez." Even so, it had not been fun. There had been kilometer after kilometer of noise and diesel fumes. More than once during the two hour trip they had nearly fainted, fallen past the spinning axles onto the concrete of Old 101. But Lu had been adamant: Their return must be realistically difficult. No one, including Wili, must suspect.

Wilma's eyes grew slightly round. "Oh, that Della Lu. She is so wonderful. Don't you think?"

Rosas looked over Wilma's head to where Della was making herself popular with the womenfolk. "Yes, she is wonderful." She had them all agog with her tales of life in San Francisco. No matter how much (and how suicidally) he might wish it, she never slipped up. She was a supernaturally good liar. How he hated that small Asian face, those clean good looks. He had never found anyone—man, woman or animal—who was so attractive and yet so evil. He forced his eyes away from her, trying to forget the slim shoulders, the ready smile, the power to destroy him and all the good he had ever done. . . .

"It's marvelous to have you back, Mikey." Wilma's voice was suddenly very soft. "but I'm so sorry for those poor people down at La Jolla and in that secret lab."

And Jeremy. Jeremy who was left behind forever. She was too kind to say it, too kind to remind him that he had not brought back one of those he had been hired to protect. The kindness rubbed unknowing on deeper guilt. Rosas could not conceal the harshness in his voice. "Don't you worry about the biosci people, Wilma. They were an evil we had to use to cure Wili. As for the others—I promise you we'll get them back." He reached out to squeeze her hand. *All but Jeremy.*

"*Da,*" said a voice behind him. "We will get all the rest back indeed." It was Kolya Kaladze, snuck up on them with his usual lack of warning. "But now that is what we are ready to discuss, Wilma, my dear."

"Oh." She accepted the implied dismissal, a thoroughly modern woman. She turned to gather up the women and younger men, to leave the important matters to the seniors.

Della looked momentarily surprised at this turn of events. She smiled and waved to Miguel just as she left. He would like to think he'd seen anger in her face, but she was too good an actress for that. He could only imagine her rage at being kicked out of the meeting. He hoped she'd been counting on it.

In minutes, the party was over, the women and children gone. The music from the trees softened, and insect sounds grew louder. Seymour Wentz's holo remained. His image could almost be mistaken for someone sitting at the far end of the picnic table. Thirty seconds passed, and several more electronic visitors appeared. One was on a flat, black-and-white display—someone from very far indeed. Rosas wondered how well his transmission was shielded. Then he recognized the sender, one of the Greens from Norcross. With them, it was probably safe.

Wili drifted in, nodded silently to Miguel. The boy had been very quiet since that night in La Jolla.

"All present?" Colonel Kaladze sat

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down at the head of the table. Images far out-numbered the flesh-and-blood now. Only Miguel, Wili, Kaladze and his sons were truly here. The rest were images in holo receivers. The still night air, the pale glow of bulbs, the aged faces, and Wili—dark, small, yet somehow powerful. The scene struck Rosas like something out of a fantasy: a dark elven prince, holding his council of war at midnight in faery-lit forest.

The participants looked at each other for a moment, perhaps feeling the strangeness themselves. Finally, Ivan Nikolayevich said to his father, "Colonel, with all due respect, is it proper that someone so young and unknown as Mr. Wachendon should sit at this meeting?"

Before the eldest could speak, Rosas interrupted, a further breach of decorum. "I asked that he stay. He shared our trip south and he knows more about some of the technical problems we face than any of us." Miguel nodded apologetically to Kaladze.

Sy Wentz grinned crookedly at him. "As long as we're ignoring all the rules of propriety, I want to ask about our communications security."

Kaladze sounded only faintly irritated by the usurpations. "Rest assured, Sheriff. No leaks from this end. If you line-of-sighters take even minimum precautions, we're safe." He glanced at the man from Norcross.

"Don't worry about us. We're using knife-edges, convergent corridors—all sorts of good stuff. The Peacers could monitor forever and not even realize they were hearing a transmission. Gentlemen, you may not realize how primitive the enemy is. Since the La Jolla kidnappings, we've had some of our bugs planted in their labs. The great Peace Authority's electronic expertise is fifty years obsolete. We found researchers ecstatic at achieving component densities of ten million per square millimeter." There were surprised chuckles from around the table. The Green smiled, baring aging teeth. "In field operations, they are much worse."

"So all they have are the bombs, the jets, the tanks, the armies, and the bobbles."

"Correct. We are very much like stone-age hunters fighting a mammoth: we have the numbers and the brains, and the other side has the physical power. I predict our fate will be similar to the hunters'. We'll suffer casualties, but the enemy will eventually be defeated."

"What an encouraging point of view," Sy put in dryly.

"One thing I would like to know," said a hardware man from SLO. "Who put this bee in their drawers? The last ten years we've been careful not to flaunt our best products; we agreed not to bug the Peacers. That's history now, but I get the feeling that *somebody* deliberately scared them. The bugs we've just planted report they were all upset about high tech stuff they found in their labs earlier this year. . . . Anybody want to 'fess up?"

He looked around the table; no one replied. But Miguel felt a sudden certainty. There was at least one man who might wish to rub the Authority's nose in the Tinkers' superiority, one man who had always wanted a scrap. Two weeks ago, he would have felt betrayed by the action. Miguel smiled sadly to

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himself; he was not the only person who could risk his friends' lives for a Cause.

The Green shrugged. "If that's all there were to it, they'd do something more subtle than take hostages. The Peacers think we've discovered something that's an immediate threat. Their internal communications are full of demands that someone named Paul Hoehler be found. They think he's in Middle California. That's why there are so many Peacer units in your area, Kolya."

"Yes, you're quite right," said Kaladze. "In fact that's the real reason I asked for this meeting. Paul wanted it. Paul Hoehler, Paul Naismith—whatever we call him—has been the center of their fears for a long time. Only now, he may be as deadly as they believe. He may have something that can kill the 'mammoth' you speak of, Zeke. You see, Paul thinks he can generate bobbles without a nuclear power plant. He wants us to prepare—"

Wili's voice broke through the ripple of consternation that spread around the table. "No! Don't say more. You mean Paul will not be here tonight, even as a picture?" He sounded panicked.

Kaladze's eyebrows rose. "No. He intends to stay thoroughly . . . submerged . . . until he can broadcast his technique. You're the only person he—"

Wili was on his feet now, almost shaking. "But he has to see. He has to listen. He is maybe the only one who will believe me!"

The old soldier sat back. "Believe you about what?"

Rosas felt a chill crawl up his back. Wili was glaring down the table at him.

"Believe me when I tell you that Miguel Rosas is a traitor!" He looked from one visitor to the next, but found no response. "It's true, I tell you. He knew about La Jolla from the beginning. He told the Peacers about the lab. He got J-J-Jeremy killed in that hole in the cliffs! And now he sits here while you say everything, while you tell him Paul's plan."

Wili's voice rose steadily to become childish and hysterical. Ivan and Sergei, big men in their late forties, started toward him. The Colonel motioned them back, and when Wili had finished, he responded mildly, "What's your evidence, son?"

"On the boat. You know, the 'lucky rescue' Miguel is so happy to tell you of?" Wili spat. "Some rescue. It was a Peacer fake."

"Your proof, young man!" It was Sy Wentz, sticking up for his undersheriff of ten years.

"They thought they had me drugged, dead asleep. But I was some awake. I crawled up the cabin stairs. I saw him talking to that *puta de la Paz*, that monster Lu. She *thanked* him for betraying us! They know about Paul; you are right. And these two are up here sniffing around for him. They killed Jeremy. They—"

Wili stopped short, seemed to realize that the rush of words was carrying his cause backwards.

Kaladze asked, "Could you really hear all they were saying?"

"N-no. There was the wind, and I was very dizzy. But—"

Sy's image stood. "That's enough, Boy." The old sheriff's voice boomed across the clearing. "We've known Miguel since he was younger than you. He grew up here—" not in some Basin

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ghetto "—and we know where his loyalties are. He's risked his life more than once for customers. Hell, he even saved Paul's neck a couple of years ago."

"I'm sorry, Wili." Kaladze's voice was mild, quite unlike Sy's. "We do know Miguel. And after this morning, I'm sure Miss Lu is what she appears. I called some friends in San Francisco: Her folks have been heavy wagon 'furbishers for years up there. They recognized her picture. She and her brother went to La Jolla, just as she says."

Has she no limits? thought Rosas.

"*Caray*, I knew you'd not believe. If Paul was here—" The boy glared at Kaladze's sons. "Don't worry. I'll remain a gentleman." He turned and walked stiffly out of the clearing.

Rosas struggled to keep his expression one of simple surprise. If the boy had been a bit cooler, or Della a bit less superhuman, it would have been the end of Miguel Rosas. At that moment, he came terribly close to confessing what all the boy's accusations could not prove. But he said nothing. Miguel wanted his own revenge to precede his own destruction.

21

Nikolai Sergeivich and Sergei Nikolayevich were pale mauve sitting on the driver's bench ahead of Wili. The late night rain was a steady hushing all around them. For the last four kilometers, the old Russians' "secret tunnel" had been above ground: When the cart got too near the walls, Wili could feel wet leaves and coarse netting brush against him. Through his night glasses, the wood glowed faintly warmer than the leaves or the netting which must have been some sort of camouflage. The walls were thickly woven, probably looked like heavy forest from the outside. Now that the roof of the passage was soaked, a retarded drizzle fell upon the four of them. Wili shifted his slicker against the trickle that was most persistent.

Without the night glasses the world was absolutely black. But his other senses had things to tell him about this camouflaged path that was taking them inland, past the watchers the Authority had strung around the farm. His nose told him they were far beyond the groves of banana trees that marked the eastern edge of the farm. On top of the smell of wet wood and roping, he thought he smelled lilacs, and that meant they must be about halfway to Highway 101. He wondered if Kaladze intended to accompany him that far.

Over the creaking of the cart's wheels, he could hear Miguel Rosas up ahead, leading the horses.

Wili's lips twisted, a voiceless snarl. No one had believed him. Here he was, a virtual prisoner of the people who should be his allies, and the whole lot of them were being led through the dark by the Jonque traitor! Wili slipped the heavy glasses back on and glared at the mauve blob that was the back of Rosas's head. Funny how Jonque skin was the same color as his own in the never-never world of the night glasses.

Where would their little trip end? He knew that Kaladze and Son thought they were simply going to the end of the tunnel, to let Wili return to Naismith in the mountains. And the fools thought that Rosas would let them get away with it.

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For twenty minutes he had been almost twitchy, expecting a flash of real light ahead of them, sharp commands backed up by men in Authority green with rifles and stunners, the La Jolla betrayal all over again. But the minutes stretched on and on with nothing but the rain and the creaking of the cart's high wheels. The tunnel bent around the hills, occasionally descending underground, occasionally passing across timbers built over washouts. Considering how much it rained around Vandenberg, it must have taken a tremendous effort to keep this pathway functioning yet concealed. Too bad the old man was throwing it all away, thought Wili.

"Looks like we're near the end, sir." Rosas's whisper came back softly (ominously?) over the quiet drone of the rain. Wili rose to his knees to look over the Kaladzes' shoulders: The Jonque was pushing against a door, a door of webbed branches and leaves which nevertheless swung smooth and silent. Brilliant light glowed through the opening. Wili almost bolted off the cart before his glasses adjusted and he realized that they were still undiscovered.

Wili slipped his glasses off for a second and saw that the night was still as dark as the back of his hand. He almost smiled; to the glasses, there were shades of absolute black. In the tunnel, the glasses had only their body heat to see by. Outside, even under a thick cloud deck, even in the middle of a rainy night, there must be enough ordinary light for them. This gear was far better than the night scope on Jeremy's rifle.

Rosas led the extra horse into the light. "Come ahead." Sergei Nikolayevich slapped the reins, and the cart squeezed slowly through the opening.

Rosas stood in a strange, shadowless landscape, but now the colors in his slicker and face didn't glow, and Wili could see his features clearly. The bulky glasses made his face unreadable. Wili shinnied down and walked to the center of the open space. All around them the trees hung close. Clouds glowed through occasional openings in the branches. Beyond Rosas, he could see an ordinary-looking path. He turned and looked at the doorway. Living shrubs grew from the cover.

The cart pulled forward until the elder Kaladze was even with the boy. Rosas came back to help him down, but the Russian shook his head. "We'll only be here a few minutes," he whispered.

His son looked up from some instrument in his lap. "We're the only man-sized animals nearby, Colonel."

"Good. Nevertheless, we still have much to do tonight back at home." For a moment, he sounded tired. "Wili, do you know why we three came the way out here with you?"

"No, sir." The 'sir' came naturally when he talked to the Colonel. Next to Naismith himself, Wili had found more to respect in this man than anyone else. Jonque leaders—and the bosses of the Ndelante Ali—all demanded a respectful manner from their stooges, but Old Kaladze actually gave his people something in return.

"Well, son, I wanted to convince you that you are important, and that what you must do is even more important. We didn't mean insult at the meeting last night; we just know that you are wrong about Miguel." He lifted his hand a couple centimeters, and Wili sti-

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fled the fresh pleading that rose to his lips. "I'm not going to try to convince you that you're wrong. I know you believe all you say. But even with such disagreement, we still need you desperately. You know that Paul Naismith is the key to all of this. He may be able to crack the secret of the bobbles and get us out from under the Authority."

Wili nodded.

"Paul has told us that he needs you, that without your help his success will be delayed. They're looking for him, Wili. If they get him before he can help us—well, I don't think we'll have a chance. They'll treat us all like the Tinkers in La Jolla. So. We brought Elmir with us." He gestured at the mare Rosas had been leading. "Miguel says you learned how to ride in LA."

Wili nodded again. That was an exaggeration, but he knew enough not to fall off. With the Ndelante Ali, getaways had occasionally been on horseback.

"We want you to return to Paul. We think you can make it from here. The path ahead crosses under Old 101. You shouldn't see anyone else unless you stray too far south. There's a trucker camp down that way."

For the first time Rosas spoke. "He must really need your help. The only thing that protects him is his hiding place. If you're captured and forced to talk—"

"*I* won't talk," said Wili and tried not to think of things he had seen happen to uncooperative prisoners in Pasadena.

"With the Authority there would be no choice."

"So? Is that what happened to you, Jonque Señor? Somehow, I don't think you planned from the beginning to betray us. What was it? I know you have fallen for the Chinese bitch. Is that what it was?" Wili heard his voice steadily rising. "Your price is so low?"

"Enough!" Kaladze's voice was not loud but its sharpness cut Wili short. The Colonel struggled off the driving bench to the ground, then bent till his face—eyes still obscured by the night glasses—was even with Wili's. Somehow, Wili could feel those eyes glaring through the dark plastic lenses.

"If anyone is to be bitter, it should be Sergei Nikolayevich and I, should it not? It is *I*, not you, who lost a grandson to the Authority bobble. If anyone is to be suspicious it should be *I*, not you. Miguel Rosas saved your life. And I don't mean simply that he got you back here alive. He got you in and out of those secret labs; seconds either way and it would be all of you left trapped inside. And what you got in there was life itself. I saw you when you left: if you were so sick now, you would be too *weak* to afford the luxury of this anger."

That stopped Wili. Kaladze was right, though not about Rosas' innocence. These last eight days had been so busy, so full of fury and frustration, that he hadn't fully noticed: In previous summers his condition had always improved. But since he started eating that *stuff*, the pain had begun leaching away—faster than ever before. Since getting back to the farm, he had been eating with more pleasure than any time in the last five years.

"Okay. I will help. On a condition."

Nikolai Sergeivich straightened, but said nothing. Wili continued, "The game is lost if the Authority finds Nais-

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mith. Miguel Rosas and the Lu woman, maybe know where he is. If you promise—*on your honor*—to keep them for ten days away from all outside communication, then it will be worth it to me to do as you say."

Kaladze didn't answer immediately. It would be such an easy promise to give, to humor him in his "fantasies," but Wili knew that if the Russian agreed to this, it would be a promise kept. Finally, "What you ask is very difficult, very inconvenient. It would almost mean locking them up." He glanced at Rosas.

"Sure. I'm willing." The traitor spoke quickly, almost eagerly, and Wili wondered what angle he was missing.

"Very well, sir, you have my word." Kaladze extended a thin, strong hand to shake Wili's. "Now let us be gone, before twilight herself joins our cozy discussions."

Sergei and Rosas turned the horse and cart around, and carefully erased the marks of their presence. The traitor avoided Wili's look even as he swung the camouflaged door shut.

And Wili was alone with one small mare in darkest night. All around him the rain splattered just audible. Despite the slicker, a small ribbon of wet was starting down his back.

Wili hadn't realized how difficult it was to lead a horse in such absolute dark; Rosas had made it look easy. But Rosas didn't have to contend with odd branches which—if not bent carefully out of the way—would swipe the animal across the face. He almost lost control of poor Elmir the first time that happened. The path wound around the hills, disappeared entirely at places where the constant rains had enlarged last season's gullies. Only his visualization of Kaladze's maps saved him then.

It was at least fifteen kilometers to Old 101, a long, wet walk. Still, he was not really tired, and the pain in his muscles was the healthy feeling of exercise. Even at his best he had never felt quite so bouncy. He patted the thin satchel nestled against his skin and said a short prayer to the One True God for continued good fortune.

There was plenty of time to think. Again and again, Wili came back to Rosas' apparent eagerness to accept house arrest for himself and the Lu woman. They must have something planned. Lu was so clever . . . so beautiful. He didn't know what had turned Rosas rotten, but he could almost believe that he did it simply for her. Were all *chicas Chinas* like her? He had never seen a lady, Black, Anglo, or Jonque, like Della Lu. Wili's mind wandered, imagining several final, victorious confrontations, until—night glasses and all—he almost walked over the edge of a washout half-full of racing water. It took him and Elmir fifteen minutes to get down and back up the mud-slicked sides of the gully, and he almost lost the glasses in the process.

It brought him back to reality. Lu was beautiful like oleander—or better—like a Glendora cat. She and Rosas had thought of something, and if he could not guess what it was, it could kill him.

Hours later he still hadn't figured it out. Twilight couldn't be far off now, and the rain had ceased. Wili stopped where a break in the forest gave him a

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view eastward. Parts of the sky were clear. They burned with tiny spots of flame. The trees cast multiple shadows (each a slightly different color). A long section of 101 was visible between the shoulders of the hills. There was no traffic, though to the south he saw shifting swaths of light that must be Authority road freighters. There was also a steady glow that might be the truckers' camp Kaladze had mentioned.

Directly below his viewpoint, a forested marsh extended right up to Old 101. The highway had been washed out and rebuilt many times, till it was little more than a timber bridge over the marshlands. He would have his choice of any of a hundred places to cross under.

It was farther away than it looked. By the time they were halfway there, the eastern sky was brightly lit, and Elmir seemed to have more faith that he knew what he was doing.

He chose a lightly traveled path through the wet and started under the highway. Still he wondered what Lu and Rosas had planned. If they couldn't get a message out, then who could? Who knew where to look for Naismith and was also outside of Red Arrow Farm? Sudden understanding froze him in his tracks; Elmir's soft nose knocked him to his knees, but he scarcely noticed. *Of course!* Poor stupid little Wili, always ready to give his enemies a helping hand.

Wili got to his feet and walked back along Elmir, looking carefully for unwanted baggage. He ran his hand along the underside of her belly, and on the cinch found what he was looking for: The transmitter was large, almost two centimeters across. No doubt it had some sort of timer so it hadn't begun radiating back where the Kaladzes would have been sure to notice. He weighed the device with his hand. It was awfully big, probably an Authority bug. *But Rosas could have supplied something more subtle.* He went back to the horse and inspected her and her gear again, much more carefully. Then he took off his own clothes and did the same for them. The early morning air was chill, and muck oozed up between his toes. It felt great.

He looked very carefully, but found nothing more, which left him with nagging doubts. If it had just been Lu, he could understand. . . .

And there was still the question of what to do with the bug he had found. He got dressed and started to lead Elmir out from under the roadway. In the distance a rumbling grew louder and louder. The timbers began shaking, showering them with little globs of mud. Finally the land freighter passed directly overhead, and Wili wondered how the wooden trestle structure could take it.

It gave him an idea, though. There was that truckers' camp to the south, maybe just a couple kilometers away. If he tied Elmir up here, he could probably make it in less than an hour. Not just Authority freighters used the stop. Ordinary truckers, with their big wagons and horse teams, would be there too. It should be easy to sneak up early in the twilight, and give one of those wagons a fifty gram hitchhiker.

Wili chuckled out loud. So much for Missy Lu and Rosas. With a little luck, he'd have the Authority thinking Naismith was hiding in Seattle! ■

CONTINUED IN NEXT ISSUE

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Jay Kay Klein's biolog

Vernor Vinge

Writers of fiction have typically been drawn from all areas of human endeavor and degrees of education. Science fiction readers have been especially blessed with having a chance to peer into the minds of physical scientists by seeing what comes flying forth from the cauldron within. Vernor Vinge has a Ph.D. in mathematics from the University of California at San Diego, and is an associate professor in the Department of Math Sciences at San Diego State University. His academic interests are in computer science, working on extensible languages (such as FORTH); numerical analysis; and word processing.

Yet, his fiction has less to do with what is often called "hard science" than with the thought processes of human beings. He illuminates what goes on when unusual events and people collide.

Vernor was a long-term reader of science fiction. He published his first science fiction story while still an undergraduate at Michigan State University in 1964. His first *Analog* appearance came in the March, 1966 issue with a novelette which was the lead story. Unusual for a lead story, by the way, this failed to get the cover illustration, since the editor with the prescience often found in *Analog* considered the issue's science fact article "Giant Meteor Impact" of special importance. With the recent presentation of new theories on what caused the dinosaur extinctions and what will happen when large numbers of atomic bombs are exploded, the article's depiction of the aftermath of a giant meteorite strike takes on real meaning. Vernor's story of chimpanzee become intelligent by close association with a computer—and its implications for human beings—may be just as prescient, however.

As a working scientist, he has too little time to write, but has managed a dozen short stories and three novels. His first book, *Grimm's World*, appeared in 1969. His third, *True Names*, has been recently issued by Bluejay Books. This short novel made the final ballots for both the Nebula and Hugo awards, with very favorable reviews in *Analog* by Spider Robinson and in *Microcomputing* by Frank Derfler. And a movie option has been taken on it!

He was born in Waukesha, Wisconsin, and grew up in Okemos, Michigan. Starting to read at seven, he remembers that the very first book read was Robert Heinlein's *Between Planets*. More than twenty years later, Vernor was to publish "Titan As a Gravitational Brake" in the *Journal of the British Interplanetary Society*. He says he started writing soon after that Heinlein encounter and persevered with it even if it did take a dozen years for a first sale. For a while, he also collaborated with Joan D. Vinge, his former wife. Vernor feels that we can choose our own futures, if only we think about them in advance, as we do through science fiction. The ramifications of his current *Analog* serial are being thoroughly explored by two sequels. ■

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THE ANALYTICAL LABORATORY

It's that time of year again: time to thank all of you who voted in our annual poll on the previous year's issues, and to give you the results. I'm pleased to report that the number of people voting was up appreciably from last year—well over 200—and I hope it will be even higher next year. This kind of feedback is very useful to us, and consequently to you.

In case you're not familiar with the procedure, we asked everybody to look over all our issues dated 1983 and list, in order, his choices for the best three items in each of these categories: serials, novelettes and novellas, short stories, fact articles, and covers. Every first-place vote for an item counted as three points, second place two points, and third place one point. The total number of points for each item was divided by the maximum it *could* have received (if everyone had ranked it #1), and multiplying that fraction by 10 gave the scores in the listing below. In principle, those scores could be anything from 0 to 10, higher numbers corresponding to greater popularity, but in practice scores run significantly lower in categories with many entries than in those with few. So, to provide a more meaningful basis for comparison, I've included in parentheses at the head of each category the score each item in that category would have received had all been equally popular.

SERIALS (6.67)

1. *Rocheworld,* Dr. Robert L. Forward (6.72)
2. *Manna,* Lee Correy (6.53)
3. *The New Untouchables,* Joseph H. Delaney (5.49)

NOVELLAS AND NOVELETTES (0.83)

1. "Seeking," David R. Palmer (4.00)
2. "Cascade Point," Timothy Zahn (1.79)
3. "The Leaves of October," Don Sakers (1.33)
4. "The Final Report On the Lifeline Experiment," Timothy Zahn (1.16)
5. "Warlord," Timothy Zahn (1.06)

SHORT STORIES (0.57)

1. "Deborah's Children," Grant D. Callin (1.40)
2. "The Reluctant Torturer," Hayford Pierce (1.27)
3. "We, the People," Jack C. Haldeman II (1.24)
4. "The Geometry of Narrative," Hilbert Schenck (1.19)
5. "Sandcastles," Mary Caraker (1.12)

FACT ARTICLES (1.43)

1. "The Blivit In the B-Ring," Richard C. Hoagland (3.32)
2. "Xenology: The New Science of Asking, 'Who's Out There?'," David

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Brin, Ph.D. (2.14)
3. "To the Stars!" Gordon R. Woodcock (1.80)
4. "Science and Creation," Poul Anderson (1.58)
5. "Flattening Spacetime," Dr. Robert L. Forward (1.46)

COVERS (1.54)

1. June: David Hardy, for "To the Stars!" (3.26)
2. February: John and Val Lakey/Artifact, for "Seeking" (2.62)
3. October: Vincent di Fate, for *The Integral Trees* (2.39)
4. November: Tom Kidd, for "Deathwomb" (2.29)
5. December: Doug Beekman, for "Cascade Point" (2.12)

The large proportional spread between them and their nearest competitors indicates that "Seeking" and "The Blivit In the B-Ring" were *exceptionally* well-received. I also note that Timothy Zahn, whose scores sometimes suffer from having too many well-liked stories in competition with each other, this time managed to grab three of the top five slots in the Novella/Novelette division.

I'm sometimes asked why I don't separate Novellas and Novelettes, as the present method makes it impossible to recognize a good many stories of considerable merit. We like to try to make sure *all* our stories have considerable merit, and the object of the Anlab is not to try to give every story a "grade," but to give special recognition to those which many readers consider *especially* outstanding. So I actually prefer not to have the fields be too small—placing first out of 30 is more of a distinction than placing first out of 10.

It's also been suggested that we run *all* the scores, but the present system doesn't lend itself to doing that in a meaningful way. It can pick out the outstandingly popular stories, but since readers aren't rating every story, a full listing of the breakdown of all votes for first, second, or third could be misleading and unfair to those stories which didn't quite make it. To give an extreme but possible example, a story which was *everybody's* fourth choice would show up on no ballots and would have a score of 0.00! So the real problem is where to cut off the list we print. We've tended to list the top five; usually there are about that many that are well and clearly out in front. This year I can't resist adding a few honorable mentions, because in a couple of categories there was some stiff competition bunched tightly not far behind the top five. Novellas and Novelettes had Susan M. Shwartz's "Heritage of Flight" and Vernor Vinge's "Gemstone" tied for a close sixth, and Marc Stiegler's "A Simple Case of Suicide" and Joseph H. Delaney's "In the Face of My Enemy" tied for a close seventh. Short stories had Jerry Oltion's "The Sense of Discovery" and Spider Robinson's "Involuntary Man's Laughter" tied just behind fifth place, with David Brin's "Tank-Farm Dynamo" and Stephen A. Kallis, Jr.'s "Murphy" not much farther back. The strong showing of those last two provide an interesting example of the diversity of Analog readers' tastes: "Tank-Farm Dynamo" is as clear a case of a "nuts-and-bolts-hard-science-fiction" story as I've seen in a long time, while "Murphy" is an unabashed twentieth-century fantasy that would be right at home in *Unknown*. ■

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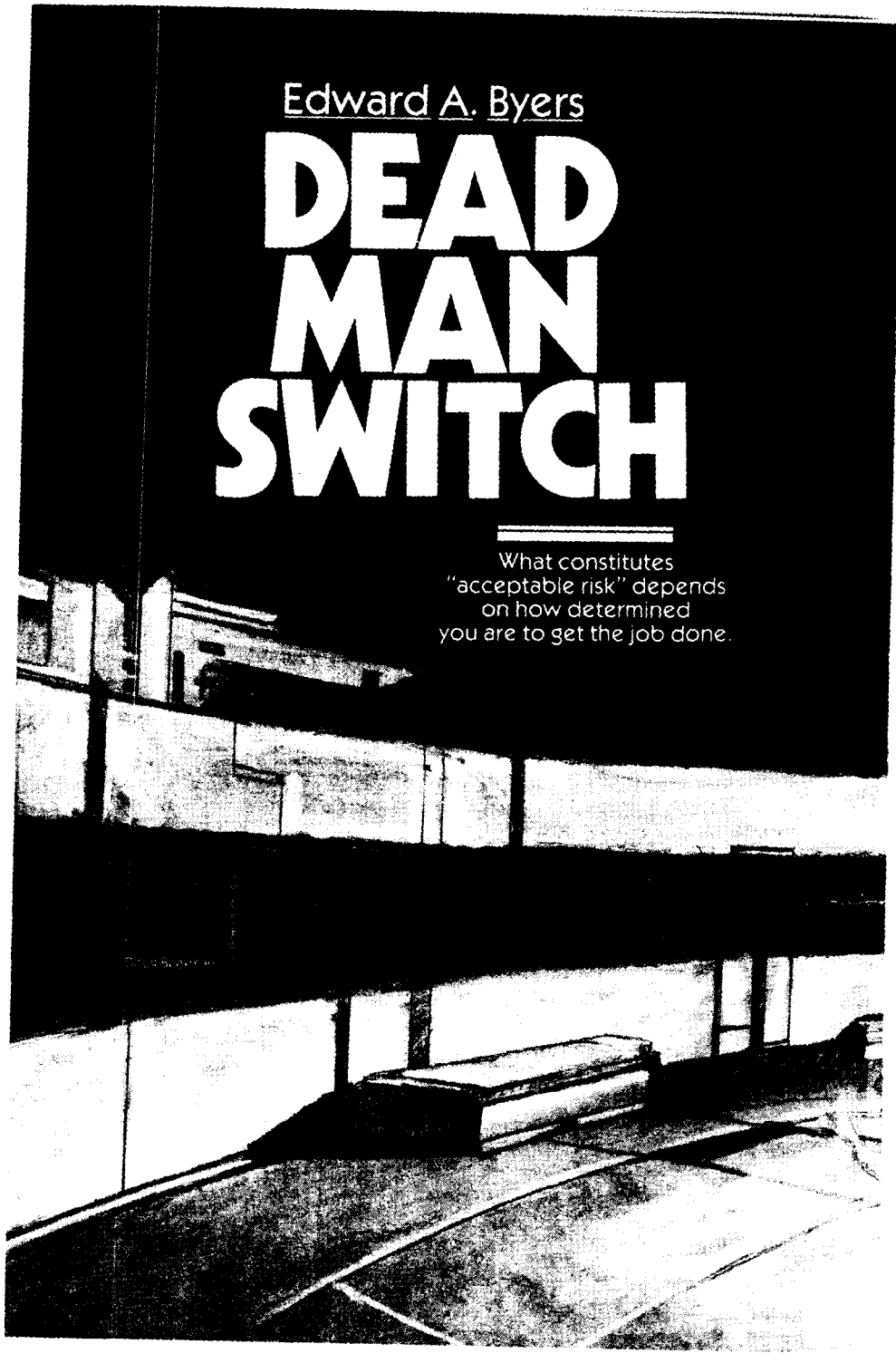
Edward A. Byers

DEAD MAN SWITCH

What constitutes "acceptable risk" depends on how determined you are to get the job done.



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Thursday. 13:20 hours.

The placard on the door to the converted stock room read:

SENATE SUBCOMMITTEE
ON ENERGY DEVELOPMENT
CLOSED HEARING

Inside, sitting in the witness chair, was a sallow-faced man of indeterminate years and apprehensive demeanor. He wore the gray whipcord uniform of the Midwest Security Company.

The voice reaching him had all the warmth and nuance of an auctioneer *en tempo*.

"You're Randolph Stone?"

The sallow-faced man nodded.

"Speak up, please, for the record."

"I'm Randolph Stone."

"How long have you been employed by Midwest Security?"

"Twelve years."

"All of them at the Mansfield Fusion Power Plant?"

"Yes." Stone's thyroid cartilage bobbed nervously up and down, giving the impression of some live thing dancing beneath the skin of his throat. He squinted, and the voice became human through the haze and halos of incandescent lighting. His chief inquisitor was silver-haired and red-faced, with substantial double chins.

"Have you ever had trouble with the anti-fusion demonstrators, the so-called Citizens Against Fusion Energy?"

"The CAFE group? They march around a lot out on the highway. They've never bothered me."

"Then you consider CAFE harmless?"

"I don't know a lot about them."

The man said, "Mr. Stone, do you know the importance of this plant's startup?"

"Sure. Everybody does. Tokamak 204 is the first fusion plant in the United States—in the world, I guess, to go on line full time. The president himself flipped the switch—all the way from Washington."

"Hmm. So you weren't surprised to have guests—dignitaries—show up at the site?"

Stone shook his head. "No sir. We've had them come in from time to time. They're all cleared somewhere else. I get a call from my chief to let them through."

"Did you recognize any of them?"

Stone raised his hands and then dropped them. "A few. There was a congressman there, I think. I remember seeing him on television. And there was the mayor of Mansfield, and one or two others."

The silver-haired man's voice turned gravelly. "We're interested in the 'one or two others,' Mr. Stone."

Stone looked mildly uncomfortable. "Well, uh, let's see. There was Dr. Saunders and a couple of his staff. Ralph Timmons, the head of Lambda. Some still photographer from the *News-Journal*, and . . ."

"Did you say Ralph Timmons?" The inquisitor's voice was frankly amazed.

"Oh, sure. He came up quite a few times while the plant was finishing its shakedown."

"That's funny." The man's voice said it wasn't at all funny. "We don't have any record of Timmons's being here during startup. Is this your logbook?" He handed a thick-lined ledger

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down across the lights. A man with slicked-back hair handed it to Stone.

"This is mine."

"Where is Timmons's entry?"

Stone examined the log carefully, running a horny finger over the page. Timmons's name was not there. There were no erasures, no blotted entries. Stone looked up, his mind going desperately back over the day of startup. Two days ago. Tuesday. Timmons *had* been there. He'd waved a cheerful hand, inquired about Stone's two kids. Something was wrong!

"He *was* here that day," Stone said defensively. "I remember giving him his badge. Number 040."

"You *think* you remember, Mr. Stone. Isn't it true you have a drink occasionally?"

Stone was sweating. "I gave that up."

"Oh?" The silver-haired man moved a little, and Stone could hear the chair squeak clear across the room. "We found two bottles of vodka—empties—in the grass alongside the guard shack. Were they yours?"

"No."

"Your fingerprints are on them."

Stone licked suddenly dry lips. For some reason the man was threatening him. He *had* given up drinking. Almost eighteen months now.

"Ralph Timmons was not here for startup," the auctioneer said heavily. "You should think about that. We don't want any mistakes on the record, do we?" The speaker nodded abruptly. The sergeant-at-arms led Stone out of the witness box.

"Who's next?" asked the man with slicked-back hair.

The man on the dais consulted a sheet of paper. "James Kinroth."

"He's project manager. A really tough cookie."

The inquisitor shrugged, straightened his stout body a little, and smiled. He ran blunt thick fingers through his mane of hair. "I eat tough cookies for lunch," he said complacently. "Kinroth'll come around."

The Mansfield Fusion Plant, officially designated as Tokamak 204 and unofficially tagged MF, occupied thirty hectares of land near the banks of the Black Fork river. It consisted of six large buildings and a central Tokamak Ring. Ninety percent of the complex was located below ground.

From his office window on the fourth floor of Administration Jim Kinroth could see one of the river's feeder streams, and just across from it a rectangular section of farmland. Two days before the section had been plowed, and soon afterwards he had seen the little girl walking back and forth in seemingly aimless patterns, staring down at the brown earth between her bare toes. What had she been looking for, he wondered.

His reverie was interrupted by a pounding on the door. Two seconds later it opened a crack and Keith Flynn stuck his long face in. It was adorned with jug ears and curly red hair.

"First figures coming in," he said. "So far everything is running within a couple of points of normal."

"Thanks, Keith." Kinroth got to his feet and went across his office to the computer console. There had been speculation that the odd circumstances sur-

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rounding startup might have wreaked havoc with the pinch effect. Tok 204 operated using a modified reversed-field toroidal zeta pinch, a rather old-fashioned magnetic field geometry. God alone knew what could occur when too much plasma got pumped into an already unstable magnetic structure. Blowout was only the *likeliest* prospect. Kinroth was both pleased and relieved that the first numbers coming off the monitoring stands detected no damage.

Flicking on the screen, he punched in a series of access keys and watched the sterile gray of the CRT change to light blue. Numbers danced across the display and the project manager grunted in satisfaction. Tok 204 was idling, producing just enough energy for breakeven. Any time they liked they could increase the plasma values and start feeding the power grids. Ohio Electric would like that.

But Ohio Electric—along with the rest of the country—would first have to await Senator Jeffrey Locke's pleasure.

Grimacing, Kinroth moved back to his desk. On its sleek surface was the small glass and metal cylinder Timmons had left him. Amplified Synapsal Projection. An ASP, he'd said it was called. A new technological toy. It hadn't been meant as a parting gift; it had simply turned out that way. Kinroth picked up the leads that ran into its crystal-metal interface and attached the flat surfaces to his temples. For the dozenth time he shut his eyes and allowed the faint electronic signal to seep through the barriers of his intellect.

It was not a thought, precisely; not a feeling, not a concept. It was an indefinable sense of . . . what? Harmony was the closest image that came to Kinroth's mind. As if someone had discovered the subtle rhythms of how things worked and this was his scratch-pad rendering.

It was only an electronic trick, of course. Third-hand hearsay. But Kinroth knew it was as close as he would ever come to spending a moment inside Ralph Timmons's head.

And that hurt.

He removed the leads and sank into the leather softness of his chair. Why did you do it, Timmons, he wondered to himself. What was the carrot? What was the goddamn goad?

As if in reply to that thought, his office door opened again. This time it was filled amply by Miss McCoullough, his severe, near-retirement secretary.

"They want you in the hearing room."

Kinroth glanced around. "Run off a record of those monitoring numbers, will you, Abby? They look okay at first blush, but I'll want to go over them with a jeweler's loupe."

The woman gave him a smile and a short nod. "I'll put them on your desk."

Kinroth stopped long enough to refresh himself. He was a shirt-sleeves manager, and no amount of polish could make him into something he wasn't. He grimaced at his reflection in the mirror. His stocky square body, with its bull-like neck and powerful shoulders, was not made for tailored suits. And his hair, brown and graying, was clubbed in a manner already two years out of fashion. He would not, he guessed, impress the government inquisitors.

They were waiting for him at the hearing room. The man with slicked-back hair had given his name as Jacob-

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son at the front gate. Kinroth suspected he was more than simply Locke's aide but hadn't pursued the thought. As he sat down in the witness box he was suddenly aware of the row of lights. They hid Locke and the others as effectively as a wall.

"You're James Kinroth?"

"Yes."

"Very well. We're trying to determine just what happened here during startup. What—and why. There are certain facts that don't add up. We would appreciate a clarification from you." Locke opened a brief in front of him and appeared to study the contents. Kinroth saw him only as a hazy silhouette.

Several seconds passed. Locke lifted his head. "Well, Mr. Kinroth? We're waiting." There was a gentle chiding quality to the man's words.

"I am, too," Kinroth said angrily. "If you'll turn those lights off we can talk. Otherwise I'm leaving."

The silver-haired inquisitor strangled on a reply. He said finally: "You're in a senate hearing, Mr. Kinroth. We make the rules here."

"Senate hearing—hell! I've heard from some who think it's a Star Chamber! Turn off those lights!" Kinroth stood up, his face menacing.

Locke turned off two of the lights, adjusted two others minutely, his features turning beet-colored.

"That's better," Kinroth said. He sat back down. "Now let's get on with it—whatever *it* is. I've got work to do."

Jacobson leaned forward a little. The project manager could have sworn the man was hiding a smile. "Tell us about Tuesday, Mr. Kinroth."

Tuesday. Startup.

Kinroth nodded. It had happened this way . . .

It was Monday afternoon.

Kinroth's grin was gleeful, exultant. He looked into the phone screen at Ralph Timmons. "Goddam it, Ralph, I'm going to put you out of business!"

Timmons gave an answering grin. The chief of the Energy Department's Lambda Bureau was tall and thin, his chin a jutting spar. His full head of hair was sprinkled liberally with gray. He said, "It looks that good, eh?"

"Goddam right! The Tok's run a hundred percent on all shakedowns. Christ, Timmons—think of it! The fusion age starts at noon tomorrow!"

Timmons's smile remained, but it took on a sardonic quality. "That's been said before, Jim."

"I know—I know." Kinroth's enthusiasm would not be shaken. "But those problems have all been solved. Tok 204 is a workhorse, Ralph, I'm telling you. Come up tomorrow and I'll prove it."

"I'll be there," Timmons said. They looked at each other for a moment, neither speaking. Timmons had sponsored Kinroth ten years before, had recommended him over a half dozen others with more degrees. Timmons had seen something in Kinroth that he had liked, some innate quality of leadership. For his part, Kinroth had found the older brother he'd never known, an intellect he could respect. More simply and most important, he'd found—a friend. For nearly two decades Timmons had sought out new energy sources, stopgapping, until the fusion plants could be brought on stream. He'd used spit and chewing

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gum and baling wire, and somehow he'd kept the grids going. Timmons had fought a delaying action with .22s, while Kinroth was preparing a cannon.

Kinroth did not sleep well that night. Dawn found him tossing uneasily. Eventually, disgusted at himself, he got up and fixed a pot of coffee. Two hours later he was at Tok 204, scanning final breakdown figures for the microwave pre-heaters.

"We ran through the sequences three times," Grady, one of the night-shift technicians, told him. "The numbers seem to be holding up."

Kinroth could find no fault with them, either, and after several minutes surrendered the sheets.

"You want us to start current flow into the mag fields?" Grady asked.

Kinroth glanced at his watch. It was six-thirty, half an hour before the day shift was due to come on. He shook his head. "We'll follow the program. We don't want any variables creeping in."

"Uh." Grady had something to say but didn't know how to say it. Kinroth waited, letting the man sort it out in his own mind.

"I know that it's essential personnel only," Grady said finally. "But I'd like to stay over, if it's okay with you. To see startup."

Kinroth put his hand on Grady's shoulder. "Stay out of the way. And check with security at shift change." Then he grinned. Grady should have something to tell his grandchildren.

"Yessir!"

By ten o'clock most of the guests had arrived. Kinroth thankfully delegated Abby to their care, saving his own time for a final walk-through of the inner and outer rings.

The heart of Tok 204 was the donut-shaped vacuum chamber in the middle of Ring One. It consisted of scores of magnetic coils—supermagnets, really—wrapped around a curving hollow core, the plasma chamber. In the bright lighting there was a vast range of metallic colors, from harsh chromium glitter to a backscatter of lambent gold.

Ring Two was dull by comparison, although here and there mirrored light skated off polished surfaces. Clad in a protective spincroft suit, Kinroth stood between the rings, the machinery dwarfing him, reducing him to less than the sum of a man. A melody came unbidden to his lips.

Catch a falling star . . .
Put it in your pock-et . . .
Never let it fade a-wayy . . .

Kinroth found himself grinning. Star-*stuff*, anyhow. And the pocket was a 300-kG mag field.

Timmons was in his office waiting for him when he got back. The Lambda chief looked weary, as though the trip had sapped his strength.

"Wait'll you see what I've got," Kinroth said, grinning, greeting the other with overt pleasure. He opened the bottom drawer of the desk and took out a wooden carton. With a flourish he pried off the top and took out a bottle brown with age. He dusted it on his sleeve, then raised his eyebrows and glanced at the Lambda man. "Cognac, from Montèlimar—and a hundred years old. I've been saving it especially for today."

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"For my retirement?" Timmons said, a smile washing away his weariness.

"No—not for that. For Tok 204. And for everybody on the god-bloody-damn planet!" Kinroth put the bottle down. "Look, Lambda's demise was inevitable. If not today, then another day—and another man doing it." He paused and took a breath. "I'd rather it was me."

"I'd rather it was, too," Timmons responded equably. He leaned back in his chair, lips twisting in amusement. One of his hands, resting on the chair arm, showed heavy scarring. Timmons was, Kinroth knew, an alganathesiac, one of those rare individuals who was unable to feel pain. Several times it had brought him near to death.

Kinroth glanced at the wall clock. "We have twenty minutes before we're needed in the control room. We can talk a little."

And, briefly, they did. Kinroth of Tok 204, explaining his world in words that grew quickly technical, until they became all but code. *High plasmas . . . betas . . . power densities . . . self-organizing sub-structures . . .* Timmons listened, nodding, seeming to follow the patterns of thought without difficulty.

At one point he changed the subject, showing Kinroth the ASP, putting the little glass and metal cylinder on the corner of the desk. In general terms, he explained how it worked.

"You mean—" Kinroth began, and then stopped, swinging toward the doorway as Keith Flynn burst through, his normally placid face ashen.

"What is it, Keith?"

"It's Grady, sir, the night tech—he put a bomb inside Ring One!"

Grady? My God! And I had told him he could stay. . . . He felt a sick knot forming in his stomach. "Where is he?"

"Security has him down in one of the suiting chambers. He says he's protesting the use of fusion power."

"I bet," Kinroth said hollowly. "Let's get the hell down there."

In suiting room three, two security guards held Grady immobile while a third meticulously searched his pockets. Kinroth stopped just inside the door and took in the scene.

"Nothing on him but this," one of the guards said. He held up a plastic button extolling the CAFE cause. In large letters were the words STOP-FUSION-NOW.

"What kind of bomb is it?" Kinroth asked, eyes centered on Grady. His voice sounded metallic in the confined quarters.

"Nothing against you personally, sir," Grady said earnestly. "We just had to stop MF short of startup."

"The bomb," Kinroth said again, curtly. "What kind is it?"

"Fermiole. Twelve pounds in a metallic sphere. It's rigged with a dead man switch." Grady had gone limp in his captors' grasp.

"What do you mean—dead man switch?" Kinroth advanced until he was only inches away from the other. Grady stirred and drew back as far as the hands pinioning him would allow.

He said, "When the first shift started powering up the magnetic fields they activated the bomb. The detonator arms are ferrite. They're held apart by a field strength of twenty Tesla. If you drop the fields any lower than that it will blow."

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Kinroth stepped back and considered. A twenty-Tesla field translated out to about 200-kG, strong enough to knock out any repair waldoes they might send out. He looked again at the technician. "What about heat?"

Grady nodded. "If you go to plasma the bomb will go off. It's set below 5000 degrees—on a magnesium trigger."

"And if we don't do *anything?*" Kinroth said despairingly. "How long do we have then? When is it set to go off?"

Grady's eyes opened wide. He seemed astonished. "Oh, no sir! It won't go off at all—as long as equilibrium is maintained."

"His aim is to *disable* Tok 204," Timmons said harshly from behind Kinroth. "First stop it, then make it into a world-wide media event. Remember, an hour from now the president is supposed to turn on the switch."

"Publicity for CAFE," Flynn muttered *sotto voce*. "And an example of how to stop any other Tok from opening."

"Bloody *hell!*" Kinroth thundered. He swung around, directed his gaze once more toward Grady. "What method was used to arm it?"

The agent of CAFE shook his head, gaining confidence. "A simple rheostat. But that's enough. Nobody can go in to disarm it. The incidental radiation alone would be enough to kill anyone trying."

"*And* the microwaves . . . *and* a 200-kG mag field." The words seemed torn from Keith Flynn's throat. "He's right about that."

"There're some non-metallic waldoes," Kinroth said dispiritedly. "But they're all located in the eastern bloc. They're going to have a field day with this."

"What'll we do with *him?*" one of the security guards asked. He gestured toward Grady.

"Lock him in here for now," Kinroth ordered. "In cuffs. We'll decide later what action to take." He turned away, toward Timmons. Only then did he realize the Lambda chief was no longer there. . . .

There was a sudden commotion at the door of the senate hearing room. Looking that way, Kinroth saw the spare figure of Keith Flynn struggling briefly with the sergeant-at-arms.

"Sorry to interrupt," Flynn got out. "There's been a little emergency. We need Kinroth for a while."

"Is there any danger?" The words were from Locke, his heavy jowls shaking as he raised his head.

"Uh, no sir. Except possibly to some equipment. There're a few impurities in the system." Flynn did not appear unnecessarily perturbed at breaking into the hearing.

Locke stared at Kinroth, then around at the others on the dais. "Very well. We'll finish your testimony later. In the meantime we can hear from . . . who, Mr. Jacobson?"

"Max Tatum," Jacobson said, looking down at a flimsy.

"Fine. You're excused for now, Mr. Kinroth."

Senator Jeffrey Locke looked down at the man in the witness box. Max Tatum was approaching retirement age, and his eyes had a wet, rheumy quality.

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His gray uniform hung baggily on his thin frame.

"Where were you when startup began, Mr. Tatum?"

The man blinked. "I have a station leading into Rings One and Two."

"Meaning you monitor everyone that passes that point?"

"Yessir."

"*Did* anyone pass that point during startup?"

"Yessir. Ralph Timmons."

Locke frowned. "Go on, Mr. Tatum. Tell us about it."

"Not much to tell. He stopped for maybe four or five minutes. He was waiting to get a clear signal from Control, I guess."

"What did you talk about?" The question came from Jackobson.

The old man shrugged. "He told me a story. It didn't make much sense, then or now."

"Tell *us* the story," Jacobson said.

Timmons was wearing one of the spincroft protective suits, its white plexicloth contrasting starkly with the deep blue of the corridor tile. He stood just outside the double airlock leading into Ring Two. As he watched, a small radiation monitor trundled into view from a cross-corridor. Tatum checked it briefly, entering the data onto a log. Then he reactivated it on a new pattern. They both watched the machine disappear into a corridor to the right.

"You do that a lot?" Timmons asked, looking from the monitor to Tatum. His voice sounded hushed, hollow, trapped inside the pressurized suit.

Tatum nodded. "Three times an hour. They're a sort of rolling check-up on our stationary monitors."

"I see. You ever hear the story of the farmer and the pig?"

The guard looked puzzled. He scratched his head. "Can't remember as I ever did."

Timmons peered at him through the dark glass of his helmet. "Man was driving down a country road, Mr. Tatum. He came across a farmer holding a pig. The pig was eating apples off an apple tree." Timmons stopped his narration abruptly, tilted his head as though listening, then talked softly, urgently, into a throat mike. His voice was too subdued for Tatum to catch the words.

Timmons straightened after a moment, looked at the guard, and resumed his story. "The pig, Mr. Tatum, was a year-old Berkshire shoat. It was eating one apple at a time. The man stopped his car, got out and watched for a few minutes, then walked over to the farmer. He was perplexed. He said, 'Why don't you just shake that tree, mister? Wouldn't that save a lot of time?' The farmer thought it over for a while and then gave a shrug. He said, 'Wull, I dunno, stranger. I mean, after all, what's time to a pig?' "

The Lambda chief did not wait for a reaction. He was talking again on the throat mike, his voice becoming clipped and compelling. Abruptly he cursed and swung around on Tatum.

"You have an airlock override here, don't you?"

"Sure, right there on the wall. But—"

Timmons was already moving past him. He tripped the override switches and ran toward the opening airlock with long purposeful strides. Just as the locks

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were closing again he turned back and waved. He said, "Good bye. Keep up the good work, Mr. Tatum."

Tatum was surprised. The man sounded almost jocular.

Senator Locke cleared his throat. "Mr. Tatum, you said the man was wearing a protective suit which obscured most of his features. How were you able to determine it was Ralph Timmons?"

Tatum looked startled. "I-I don't know. It just *seemed* to be him."

"Ah." Locke shook his head, gave the security man a tiny smile. "No, Mr. Tatum. It was not Timmons."

"*Then who*—?"

"We'll determine that in good time," Locke said. He nodded at the sergeant-at-arms.

Friday. 08:12 hours.

Seated in the witness box, Kinroth once again felt the stares of half a dozen pairs of eyes.

Senator Locke straightened fractionally in his chair, squinted across at the project manager. "I'm glad to hear there was nothing seriously wrong with the power plant."

Kinroth nodded shortly. "Ring Two is a storage ring armed with pre-heaters. It was overloading. We had to dump a little hydrogen."

"Very well. Perhaps then we could begin again where your testimony left off."

"Sure," Kinroth said. He frowned, remembering . . .

The light above the control room door was blinking on and off. A high-pitched warble sounded throughout the Tok complex. Kinroth stepped up beside Calvin Bonds, the control coordinator. In front of Bonds half a dozen CRT screens showed different aspects of Rings One and Two. Startup was fourteen minutes away.

"Stabilize and hold," Kinroth said tersely. "There's a bomb somewhere down there."

Bonds pushed his wire-mike away with one hand and looked up. His face was shiny with sweat. "That's not all that's down there! Some fool hit the airlock overrides. He's inside the Ring area now."

"What?" Kinroth got a sinking feeling in his gut.

"I tried to hold him up outside the locks," Bonds said. "But he saw through it and went in."

"Where is he now?"

"Right about—*here!*" The control coordinator punched up two new cameras on the CRTs. One of them targeted a tall figure in a spincroft suit. Kinroth grabbed a wire-mike.

"Ralph! What the hell are you pulling? Get out of there!"

The reply was muffled, but clear enough. "I'm disarming the bomb, Jim. Stick to the startup schedule. No variations."

"But why? Dammit, man—you won't get halfway to Ring One. Don't try it!" Kinroth realized he was yelling and forced himself to relax.

Timmons started toward Ring One. The control coordinator punched in a phalanx of screens following the man's movements.

Abruptly Bonds gasped.

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"He's glowing, for God's sake! Look at him!"

The richly ionized air was turning Timmons into a moving statue of fire. Halfway to Ring One he stopped. "You still monitoring this, Jim?" Timmons's words were faint, fractured with bursts of sizzle.

"I hear you," Kinroth said. The air in his lungs felt hot.

"When I go inside the Ring, give me a count of thirty. Then start the pre-heaters." Timmons's voice sounded almost conversational.

"TEN MINUTES!" a voice called over a loud speaker. Bonds looked at Kinroth, then flicked a half dozen toggle switches. He nodded at a face that appeared in one of the screens.

"START PRE-SEQUENCING!"

Timmons disappeared from view beneath the Ring's outer support work. Though he could no longer see him, Kinroth mentally followed the man's movements. Directly in front of him would be the repair hatch, ingeniously built to slide back upon itself.

"PRE-HEAT COUNTDOWN!" The voice started at thirty and began to count backwards. Kinroth pictured Timmons crawling around the cramped curve of the plasma chamber. By now his flesh would have begun to peel away from his bones and his head would be full of so-called "mag-phosphenes," the flashes of light reported by technicians even in a relatively light five-Tesla field. Blood pressure would be crashing down to nothing. The spincroft suit would help, but not very much. In moments movement would become lethargic, ragged.

"START PRE-HEATERS!"

Kinroth became aware of a thudding sound. He realized a moment later that it was his fist pounding on the console cover.

"COMING UP ON PLASMA!"

"Goddam!" Kinroth couldn't see the CRTs. His eyes stung. Bonds flicked his hands nimbly over the controls, said, "Go ahead on plasma!"

Lights flashed on the console. The screens targeted on the inner Ring showed no change.

"WE'VE GOT PLASMA!"

"There was one hell of a burp," Bonds said, looking from the screens to Kinroth, "but we've got plasma!"

Oh—yes! We've got plasma. Have we ever got plasma! Kinroth turned half away, his mind numb, his sense of loss just beginning.

The silence inside the hearing room endured for fifteen or twenty seconds before Locke spoke.

"Do you know why he did it, Kinroth?"

Dully, Kinroth shook his head.

"Because Tokamak 204 had to open on schedule. Timmons realized that."

"What do you mean?"

Locke steepled his hands, looked at Kinroth appraisingly. "All the eggs were in one basket, that's why. *Your* basket, Tok 204. If the CAFE group had succeeded they'd have delayed any further implementation of the fusion program for at least five years."

Kinroth stared. "How is that possible?"

"Simple. There's a large grass-roots opposition to fusion—the CAFE people represent only the tip of the iceberg. And this is an election year. Unless 204 works, funding will be slowed to a trick-

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le." Locke waited for Kinroth to speak. When he did not, Locke continued. "That's why there must not be a breath of scandal about this startup. That would be unmitigated disaster."

Kinroth's head lifted.

The silver-haired senator looked at him, nodded slowly. "It must never be known that Timmons died here. We've convinced everyone else of that. You are the only one remaining."

Kinroth lowered his head and stared dully at his hands. "You want me to deny that Timmons was here at startup?"

"Yes."

There was a moment of silence. "I'll let you know tomorrow," Kinroth said at last.

Kinroth put the hundred-year-old cognac back in its wooden coffin and returned it to its drawer. He sat down, pondering the events of the past few days, something very like a fist tightening inside his gut.

And God said, let there be light . . .

But Timmons *was* the light. Quite literally. The power within Ralph Timmons would go out from Tok 204 to turn on the lights of a city, to turn on toasters for early morning breakfasts, to run thousands of electric toothbrushes. A million television screens would light up because of Ralph Timmons. Kinroth imagined Timmons running irrigation pumps in Texas, milking machines in Iowa, channel buoys in Louisiana bayous. If ever a man had reached his potential, Timmons had.

He picked up the leads of the ASP and placed them on his temples, sensing the final faint ghost of the man. He looked out the window. The little girl was back, walking in random patterns over the plowed earth.

Out of impulse he left the complex, heading toward the girl. Locke was wrong—he had to be. Timmons had not sacrificed himself so that a politician in Washington could flick a switch on time. No, it had been for some other reason. Closure, maybe. The need to finish something once it's been started. Kinroth thought about that. It made sense, in a way. It fit in with the feeling engendered by the ASP. *Rhythms of how things work . . .* Tok 204 was the Lambda Bureau's death knell. It had taken away Timmons's autonomy. Briefly, for a single glorious moment, that autonomy had been given back.

Satisfied in his own mind, Kinroth reached the plowed field. The girl was about ten or eleven, with straw-colored pigtails. She was wearing denim coveralls and white tennis shoes.

He said, "Hello. What are you doing?"

"Looking for arrowheads," the girl said. "I found four the day before yesterday. Not counting possibles. I don't count possibles."

"Oh." Kinroth looked at the earth

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and then up at the rising profile of Tok 204. He said, "Mind if I join you?"

"Okay."

By midafternoon Kinroth and the girl had discovered three more arrowheads and two possibles. It was one of the nicest afternoons he could remember.

Article from the *Mansfield News-Journal:*

The body of Ralph Mason Timmons was found yesterday in the burned remains of a light plane that crashed in Mohican State Park just east of here. Timmons, 52, had been for eighteen years the director of the Lambda Bureau, a branch of the Department of Energy. Ironically, the bureau was discontinued the day after Timmons's tragic accident. He was the sole occupant of the plane.

Rhythms . . . ■

ON GAMING

(continued from page 93)

been divided evenly among the players, each player places Weyrleaders and Weyrwomen on the major Holds to form alliances with Lord Holders. All players then "bid" in secret, by placing a face-down Marks piece, to win that Lord Holder to their side. The highest bid wins; no alliance is made in case of ties; and all Marks are expended even if the bid is unsuccessful.

After the alliances have been made, Threadfall is determined by drawing cards and placing Threadfall markers on the Holds indicated. Players then attack the Thread by placing their dragon flights markers, and Weyrleaders and Weyrwomen not used during the previous alliance phase, on the Thread. You can ask other players to participate in the attacks on the Thread in your areas.

Dice are rolled for the attacks, modified by the size of the dragon flight, the personalities of the riders, and events, such as unpredictable or "strange" Threadfall. If the attack destroys the Thread, the Weyr(s) receive Marks as reward. If the attack fails, that Hold is Threaded and the spores burrow into the ground. For failing to stop the Thread, the Weyr(s) involved in the attack are fined Marks.

This sequence of play, including rebuilding injured flights, continues until all Lord Holders are allied and no burrowed Thread remains on the map. The player with the most Lord Holders wins, or, in case of a tie, the one with the most Marks is the winner. If 10 or more Holds have burrowed Thread on them at the end of any turn, the game ends and everyone loses.

Dragonriders of Pern is best played with three to six players. The negotiating and bidding for control of the Holds, combined with the tactical attacks on Thread, make for an enjoyable evening of gaming. If you like Anne McCaffrey's novels, you'll find the game captures much of the flavor and intrigue of her series. ■

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the reference library

By Tom Easton

The Branch, Mike Resnick, Signet, $2.50, 191 pp.

The Throne of Madness, Somtow Sucharitkul, Pocket/Timescape, $2.95, 255 pp.

Planet of Flowers, Warren C. Norwood, Bantam, $2.75, 240 pp.

The Wild Shore, Kim Stanley Robinson, Ace, $2.95, 384 pp.

Cugel's Saga, Jack Vance, Pocket/Timescape, $14.95, 334 pp.

The Omega Point Trilogy, George Zebrowski, Ace, $2.75, 295 pp.

Guess What's Coming to Dinner? Scott Fivelson, Bantam, $3.95, 114 pp.

Shadows 6, Charles L. Grant, ed., Doubleday, $11.95, 181 pp.

The John W. Campbell Awards, Volume 5, George R. R. Martin, ed., Bluejay Books, $7.95, 272 pp.

Dark Valley Destiny: The Life of Robert E. Howard, L. Sprague de Camp, Catherine Crook de Camp, and Jane Whittington Griffin, Bluejay Books, $16.95, 416 pp.

Isaac Asimov's Magical Worlds of Fantasy 1: Wizards, Isaac Asimov, Martin H. Greenberg, and Charles G. Waugh, eds., Signet, $3.50, 304 pp.

New Earths: Restructuring Earth and Other Planets, James Edward Oberg, Meridian (NAL), $8.95, 283 pp.

I have been challenged to stick my neck out, way out, where anyone with a nicely whetted axe can take a whack at it. The challenger is Mike Resnick, who writes that it's been ten years since anyone dared to try to list and rank the eight or ten best writers at work in the SF field. He urges me to have a go at it.

I'm not so sure that's a real good idea. I'm not even sure that it's possible to say, "Here is the best, the second best, the third best, etc., for all of SF." The problem is that SF is not a single literary mountain, but more like a range of mountains with many peaks. That is, there are a great many different varieties or subgenres of SF, each variety has its

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own hierarchy of writers, and the bests are not strictly comparable.

Therefore, what I will do is give you my list of hot young writers, those people who have appeared in roughly the last decade and achieved some distinction in my own mind. They are not all prolific, or best sellers, or award winners. I will also mention a few I believe to be overrated. I will discuss very few at any length, so there should be plenty of opportunities for you to wave your axes.

Let's start: C. J. Cherryh started strong and has kept it up, with a good, thorough imagination, generally lively stories, and sometimes potent "literary" qualities. John Varley has done some very nice work, but his production has slowed to the point where I sometimes wonder if he's still writing. Orson Scott Card seems to have sputtered out after early promise. Barry B. Longyear has sputtered too; he seems to be doing most of his work in non-SF areas lately, though he may have a few good tales in him yet. Somtow Sucharitkul is improving like wine with age; his multicultural viewpoint may yet give us the best SF novel of all time. Charles Sheffield is consistently strong and satisfying, but perhaps he will have to retire from his job with the Earth Satellite Corporation before he can give himself the time to do the truly major piece of work of which I believe he is capable. James Hogan is sometimes good, always competent, and always too talky to be great. David Brin may have more potential for major work than Sheffield; he has already come very close. Robert Stallman and Tom Reamy are the two damnedest shames of the past twenty years. Paul Preuss is right up there with Brin and Sheffield—watch all three for future marvels. Hilbert Schenck is a marvel already, and he may be one of the current peak-sitters. Octavia Butler I wish we had more from. Crawford Kilian raised high hopes with *Eyas* but hasn't met them yet.

I'm not sure myself which of these people is best right now. My opinions change with every book I read. On the other hand, I can venture a prediction that Cherryh, Sucharitkul, Brin, and Preuss (and maybe Sheffield and Kilian and Varley) will be on everyone's lists of all-time bests in the future.

WRITERS: If your name is not in the above list, either I don't think you belong in it, I think it's too soon to evaluate you properly, or I overlooked you. Jo Clayton? Began well, but seems to have matured as a minor talent. Bob Asprin? Fun, but minor. Joan Vinge? She's done at least one very good piece, but she may never sit a peak. Jack Chalker? He seems barely worth critical attention; he does sell well, so I may be wrong (and see below).

Did I overlook Resnick himself? Nope. I was just saving him for now. His latest novel is **The Branch**, and it does such a marvelous job of goring sacred oxen that, Mike tells me, his first two rejection letters called it obscene and blasphemous. Really, it's just sacrilegious, with a touch of prurience, and a lot of lead-up to a shaggy-dog punch line of sorts.

The Branch is set in a world so prosperous that people are bored stiff with all their leisure. They go for religion, hobbies—some of them bizarre—and gambling, among other things. Solomon Moody Moore is an underworld chieftain, grown wealthy by catering to the bored. Jeremiah the B is a ne'er-do-well bum of low moral character who offends Moore, but whom Moore cannot seem to kill—bullets miss and gadgets jam. Why? Jeremiah the B is the last

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scion of the tree of David, childless, and vasectomized. Therefore, he *has* to be *the* Messiah, destined to establish a Jewish kingdom in Jerusalem. Of *course* Moore can't kill him.

Given this situation, Resnick handles it well and humorously, and—as usual—with a point. He tells us in a prologue that though people are bored, they won't be bored for long. He says that a world without religion, without churchly crutches, would be a more interesting place to live. He might even be right, but he only says it. He tells us. He never shows us such a world in action, and he doesn't really convince us.

Still, Resnick is up to very much the same kind of thing as in all the other books he's produced in the last year or so. And it's probably time to try to summarize what that is. He writes much like most other SF writers—clearly, straightforwardly, directly, without fanciness—but he does *not* write the same kinds of stories. There is always a point, a theme, clearly embedded in the core of his tale, and the tale itself is designed to carry that point home, as a bow an arrow. Other writers often have no point or too many points, or the points are smothered in bubbles.

Am I on target? Mike writes me that I do keep naming his points as he knows them himself, even as he complains that other reviewers miss them. In his last letter, he says:

> In the broadest sense, I'm telling moral parables, and using science fictional backgrounds because (1) SF is easier to sell, especially in the quantity that I like to write, and (2) it's easier to set up a moral parable with all time and all space to play with. I'm also trying to tell stories (for and) about adults, with adult problems and adult motivations in an adult universe, which seems to be increasingly rare in the field these days.

Perhaps maturity is so rare because the market studies keep telling the publishers and writers that most SF buyers are young, but there must be a fair number of adult readers, too. Mike's stuff does sell, after all. At any rate, he goes on to say that where certain other writers proudly proclaim that they write the kind of stories they wanted to read when they were twelve years old, and get cheered for it, he is:

> trying to write exactly the kind of stories I want to read at age 40—and next year I'll be writing what I want to read at 41.
>
> I have always felt that accessibility is the most important single quality a writer can possess. . . .

He *is* accessible, and what he does he does knowingly. His tales are parables, fables, perhaps even lengthy aphorisms, and he occupies a peak all his own in the mountains of SF. He may not have many direct competitors, but he writes well enough not to worry how crowded the slopes might be.

When I praised Somtow Sucharitkul above, I was thinking of *Starship and Haiku* and of his latest, **The Throne of Madness**, the second volume in his Inquestor Trilogy (the first was *Light on the Sound*). Here, Ton Davaryush is defrocked and banished to Shtoma, world of the sentient, loving sun. His protégé, Kelver, is an Inquestor in training, sent on the lonely journey across the Inquest's home globe (it encloses the galactic center), on which he will find his fate. He has companions, one female and true, one male and fickle. He seeks and finds the Throne of Madness, with which he hopes to destroy the Inquest. He mounts a war of compassion, but one of aid, not the pain the

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Inquest calls Compassion. He sees cities built in the heads of monster snakes and destroyed in the snakes' mating throes. He sees. . . . Enough. Somtow gives us wonders galore, mythopoeic scope and sweep, images and destinies to haunt the imagination. His failure, if any, is his lack of restraint; for in such a sweeping tale there is too little to engage a reader's empathy. Yet even so we feel for Kelver, and I am more convinced than ever that Somtow's will be a name to conjure with, probably before the 1980s are done.

Though Warren Norwood also suffers from a lack of restraint, I might have put him on my list of present and potential peak-sitters if he weren't so newly on the SF scene. He may yet sputter out. If he does, I'll regret it, for he shows great promise to be fulfilled as soon as he chooses to paint his tales on smaller canvases—he doesn't really need the broad borders in which his Windhover Tapes series is set.

I have here the fourth and final Tape: **Planet of Flowers**. It's told in the third person, its canvas is relatively small—for Norwood—the ship *Windhover* is very much in the background, there are no afternotes to give the tale a spurious academicity, and the book is the best in the series. It also does a great deal to pull the series together, for Fairy Peg's sister appears from the Ribble Galaxy with Gerard Manley's byblow son to spur his memory to completeness. In addition, a consortium of immortal aliens appears to tell us Manley is a many-lived construct, the Verporchting, made by one of them as a toy. Another toy is the species of sentient flowers that gives the title planet its name. There Manley struggles for memory and survival, and learns that he is himself the Tenderfoot whose myths, legends, and poems he and his triple-breasted wife ShRill have been seeking all along. There too he becomes. . . . I won't tell you. It is enough to say that the ending is an ending indeed, it satisfies, and it reveals Norwood as potentially a very major talent.

Kim Stanley Robinson's **The Wild Shore** is the first of the new Ace Specials to emerge from Terry Carr's editorial shop. Carr promises that the new Specials will not be "skilled (or not so skilled) rehashings of plots and ideas that have been popular in the past" or "timid and literarily defensive." They will "have something new to add in ideas or literary development" and be "by authors . . . comparatively new to science fiction." *The Wild Shore*, he says, "adds a depth of characterization and background that has rarely been approached in science fiction before now."

Does it, really? No. The characters are handled well, but no better than we've often seen in SF, and there are no memorable characters, except—in a low-key way—Old Tom, elder and teacher of a post-holocaust community in an America quarantined from the rest of the world until American voracity has disappeared from the minds and genes of the remnant populace. The background is nicely textured, but no more so than we have also seen before.

How about new ideas? There's Robinson's quarantined America, its West Coast patrolled by Japanese ships to prevent escape and, ostensibly, trespass. All else is either familiar— scavengers, relict technology, power trippers, fear of renaissance —or corollary. The latter category certainly covers the dreams of the teen-aged protagonists who deal with the scavengers, spy hornily on collaborators, dream of escape, and guide

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the forces of a rebuilding technological civilization into battle with the Japanese.

If the story doesn't live up to all Carr's claims, it is nonetheless quite good enough to fit any of the older "quality" lists. But I wish Carr hadn't written the introduction he did, for then I could have praised the book more unreservedly, and I would have.

Heed the lesson, editors: Never, never feed the bears! Hand a reviewer a ready-made criterion, and he is bound to try to shoot it down. (And that goes for blurb writers and PR folks, too.)

In the 1950s, Jack Vance splashed into SF with *The Dying Earth*, which introduced Cugel the Clever, a scamp, rogue, and opportunist whose troubles were almost entirely his own doing. In the 1960s, he continued Cugel's tale with *The Eyes of the Overworld*. Now he gives us **Cugel's Saga**. Cugel, once returned home to Almery and the Laughing Magician, Iuconnu, was promptly tossed back across the world to Shanglestone Strand, where he had had to begin his last trek. He is quite justifiably mad at Iuconnu, but he can't do a thing until he gets back to Almery once more. Yet he can't follow his old route—the people who live along it have long memories.

So he turns the other way, to find Flutic, a mean-souled collector of demon scales. When Cugel leaves him, he bears the Pectoral Sky-break Spatterlight, the demon's central scale which, combined with all the others, will revivify the demon. He has hopes of using it against Iuconnu, who is Flutic's patron and to whom all the scales are shipped.

Through piracy, sharp practice, fast talk, and extraordinary luck, Cugel makes it. He leaves behind his usual trail of disaster, empty pockets, and ravished virgins, and at the end of his trail he actually comes out on top. His world bears the strange names, the color, the quirky arbitrariness of all Vance's visions. There is a strong flavor of fantasy, but in *Saga* there are—if my memory serves—more indications of science behind the magic, so that Cugel's dying Earth reminds strongly of Gene Wolfe's Urth in many ways. For all his color, though, Vance gives us less of a sense of place, so that readers who seek more of Wolfe's unique stew will find here little better than watered soup. It doesn't help that in places—notably the transition between the first two chapters—the cook seems to have been a trifle hasty.

George Zebrowski's **The Omega Point Trilogy** is an oddly reworked book. Its middle section, *The Omega Point*, appeared in 1972 and is revised here. Its first section, *Ashes and Stars*, 1977, is also revised. Its final third, *Mirror of Minds*, appears here for the first time. And I'm not sure it's worth the trouble.

The story: Gorgias is one of the last survivors of the Herculean Empire, a race of genetically engineered human-alien hybrids with an acquisitive, expansionist turn of mind. When they provoke Earth humans, they are properly destroyed and their worlds are sterilized. Gorgias wants revenge, and he has an empty base and a super-ship to use. Unfortunately, though he is clever in some ways, he is dumb in others, and that is his downfall.

The story rises above this triteness in the person of Myraa, another survivor, the leader of an isolated colony of refugee Herculeans, and the "priestess" of a strange cult. She has the power to absorb the souls of the dying. Her goal

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is the accumulation of a critical mass of souls that will form Omega, a godhead, a nonimperial imperium. Her interactions with Gorgias and with the humans who hunt him make a far more satisfying tale, and the book's last portion, *Mirror of Minds*, is by far the best. Here, and as he approaches it, Zebrowski gets potent and vivid. In the earlier parts of the book, his prose is too often clumsy, awkward, overwritten, and emotionally obsessive. The book thus takes too long to repay the reader. Don't waste your money on it.

Scott Fivelson's **Guess What's Coming to Dinner: The Extraterrestrial Etiquette Guide** is a funny-hat gift book loaded with tips for humans and ETs on how to behave when the two meet over the dinner table, at parties and work, in sports and courtship and abduction. It has some nice cartoons by John Caldwell, and it's loaded with references for Warty-Trekkies and ET-poos (e.g., "An E.T. always checks his umbrella, unless he's expecting a call").

I tipped my contact at the *National Enquirer* that here might be a good excuse for an article on E.T.-quette. And now you know.

Charles Grant has now committed **Shadows 6**, but the book is hardly a crime. Every one of its sixteen stories is good. The best are Marc Laidlaw's "Sneakers," Elisabeth Burden's "Dreams," Steve Rasnic Tem's "Crutches," and Pat Cadigan's "Eenie, Meenie, Ipsateenie." The best of all is David Morrell's "But At My Back I Always Hear." Morrell wrote *First Blood* and other grueful chillers, and here he's done it again. The tale offers us a college prof and a student who is convinced she hears his voice declaring passionate love for her unappealing bod. He sends her away, she leaves school, and some time later she phones him at 3 A.M. She's still hearing his lust, and she will come to him all the way from California. She calls again the next night, and the next, and the prof learns she died the night of the *first* call. The calls come earlier as she crosses time zones, he sends his family from his house and flees eastward himself. The calls keep reaching him. And . . . finally . . . there's no call. But the doorbell rings.

What a delicious chill that gave me! And there are others to do the same.

George Martin's *New Voices* is back at last, from a new publisher, as **The John W. Campbell Awards, Volume 5**. A bit behind schedule, this one offers new stories from the Campbell nominees for 1977: Jack Chalker ("In the Dowaii Chambers"), M. A. Foster ("Dreams"), Carter Scholz ("A Catastrophe Machine"), and C. J. Cherryh ("Companions," plus a short reprint). The Chalker, in which an anthropologist becomes an anthropological sample, makes me wonder about the justice of my comment above that he is not worth much attention; if he were this good all the time, he would be a real force in the field. Foster's piece is an odd analysis of love in the cracks of civilization. Scholz's is not really SF, but a study of a mathematician's life. Cherryh's posits a survey ship that loses all its crew but one to plague; that one then teaches his ship's computer to play companion, with all too human results.

With luck, Martin will catch up to the present year rather sooner than seven years from now. His anthologies are well worth collecting.

With the interpretative assistance of the late Jane Whittington Griffin, a psy-

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chologist who long taught child development at the University of Pennsylvania, L. Sprague and Catherine Crook de Camp have written the first full biography of Robert E. Howard: **Dark Valley Destiny**. Howard, best known as the creator of Conan, shot himself in 1936, at age 30, when he knew that his mother would never wake from her terminal coma. His mother had bound him to her with the most potent of bonds, she and his father had stifled his independence and his sense of reality, and he was full with a towering rage that came out largely in his work—fantasy as wish-fulfillment.

It's a sad story, and basically a short one which the de Camps have drawn out with long discourses on family background and Texas geography and history. I don't care for the lectures much, for though they definitely do add to our sense of Howard, they could have done as much at lesser length.

Howard's work is now widely and easily available, so those who first meet him in the de Camp biography will have no trouble finding his stories. One of his best, "The People of the Black Circle," is included in **Isaac Asimov's Magical Worlds of Fantasy 1: Wizards**, edited by Asimov, Martin H. Greenberg, and Charles G. Waugh. This book also includes selections by Vance, Goulart, Niven, de Camp, Bear, Le Guin, Jakes, Wellman, and Cogswell; some are classics.

James Oberg's **New Earths: Restructuring Earth and Other Planets** reprints a 1981 Stackpole book. Its topic is terraforming of Earth herself, Mars and Venus, the Jovian moons—whether and how and when. The schemes hatched on fertile drawing boards boggle the mind like fiction and have more sweep and scope and grandeur than many stories. However, Oberg omits so much detail and simplifies so much biology (at least) that he doesn't always convince. I would find more satisfying a single book on how we might take control of Earth's climate in the future, or on how we might make Mars or Venus habitable. This book lists project after project so briefly that it is far more a catalog of possibility, and perhaps a call to arms, than a real discussion of the practicalities of terraforming.

Still, it's thought-provoking, inspiring, and awing. Writers must find it a mine of story ideas. Politicians must shudder at the projected expenses. Voters must wonder at the sanity of government and academic dreamers. SF fans must be delighted, for here indeed are the wonders of the next few centuries. ■

● All men should let their conduct be guided by the same principles, and those principles should be such, that by following them there should accrue to all as great a measure as possible of security and satisfaction, and as small a measure of suffering.

Albert Einstein,
Out of My Later Years

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brass tacks

Dear Dr Schmidt:
Ordinarily I would not comment on a story in *Analog;* however the story "The New Untouchables" has been bugging me, and so here goes: The premise of the story seems to me somewhat weak. Society's reaction to the Alban Test, an indicator that some chemical dysfunction may underly all criminal behavior, is remarkably one-sided. Nowhere do we hear of the outcry for some cure, based perhaps in genetic manipulation or chemotherapy or the like. Where have all the technofix people and the liberals gone? It (the Alban Test) would certainly strike me as a pointer to such a cure for criminal behavior. While I do see some analogy to the growing and alarming use of polygraph tests in employee and job applicant screening, I wonder if the approach wasn't stretching reality a bit more than is the wont of *Analog* stories. Perhaps Mr. Delaney would comment.

WILLIAM GAHERTY

Boston, MA

The author replies:

Mr. Gaherty has faithfully repeated all the mistakes that the general public made in the story. He should read it again, noting the following points.

Point one: A careful reading of the story will reveal that the Alban syndrome was *not* the underlying cause behind criminal behavior, so it was *not,* as he says, a pointer to a cure for criminal behavior. Nowhere in the story do I claim it was. Sure, statistics *proved* it was, but statistics *prove* lots of things that aren't so. I recall reading a letter in Brass Tacks one time, where the writer statistically *proved* John W. Campbell didn't exist.

Point two: The founder of the Children of Cain was a physician, certainly interested in finding a cure, but ham-

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pered by the fact that he was also a victim. Ceil Alban worked hard on that too, and when the story ended the search for a *cause* was still going on. Curing is usually a whole lot easier once cause is known, and it's no help at all to have the world in turmoil while you're looking for the cause.

Point three: The main thrust of the story was to point out how paranoia can temporarily overcome reason in even the best of organized societies. Society had become a mob entity, as it has been before, and will be again. When that happens it always takes a while for things to get back in synch; for cooler heads to sort things out, recognize problems, explain them to their slow witted neighbors, and solve them. Naturally this is going to be a little bit chaotic, particularly if some people don't really want the problem solved, like truly criminal positives for instance. They had no incentive to complain, because the enzyme made their life easier. And, normal people were afraid of the positives.

Therefore the public persecuted them, just as they did 100,000+ loyal Japanese-American citizens in 1942, who also bore the Mark of Cain.

Who spoke up for the Nisei—*then?* Oh, sure, I know, the rest of the country is ashamed—*now*. The Nisei didn't take to the streets and scream obscenities at their government. Their sons didn't march across college campuses burning their country's flag. They were too busy *bleeding* for it. Don't tell me what happened to them can't happen to you. It can. The question is, can you behave as honorably as they did if it does happen to you? Our shame was their just revenge. Why else would they trade a nice, safe life in a California concentration camp for a grave full of Italian mud?

Only *law-abiding* positives did anything constructive. Only they *could* have done anything. And they very sensibly did it through the courts—because they knew the courts *had* to listen to them. That is the lesson in "The New Untouchables": the system works. The crazies can't take over, unless the rest of us wreck the system first.

Where were the liberals, he asks. Presumably, they were where they always seem to be; where it was nice and safe. Liberals are a practical enough bunch where their own hides are at stake. Maybe that's why so many "demonstrations" are held in Washington, where all it takes is a big mouth and a good TV profile, instead of in Moscow, Peking, Warsaw, Prague, etc., where it takes *real* guts. The supreme test of any conviction is whether or not you're willing to bet your neck on it. My characters were.

Point four: In my opinion we have little to fear from polygraph tests. They're too controversial, and lawyers are used to them. But, I wonder if Mr. Gaherty is aware that some employers already test employees' genes for sensitivity to chemicals they make or use—and legally fire, or refuse to hire those who flunk. Now just suppose your employer. . . .

Point five: Room. There were many points the *Analog* version didn't touch on, including what was happening outside the U.S. (Another, longer version does exist). Any time an editor can give me the space, (and usually they can't), I can fill it up. Most of the time, however, it's necessary for the reader to fill in details with his own imagination, if he has any.

JOSEPH H. DELANEY

Dear Mr Schmidt,
I have been meaning to ask you for some

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time about the phone-in subscription advertisement which runs occasionally in Analog (most recently page 73, June 1983). Who makes phones with base 8 dials?

MARC W. MILLER

Normal, IL

Good question! I'm obviously going to have to stop by the office where they produce those ads and have a close look at their equipment (and the beings using them!).

Dear Dr. Schmidt,

I recently picked up a copy of the October 83 Analog and read Jerry-Pournelle's article denouncing the "Voodoo Sciences." Mr. Pournelle has made the unfortunate error of equating technicians with scientists. Scientists are people who ask questions in an organized manner. As a final step in the process of asking questions and testing answers, scientists *may* reach a point in which their analysis of the subject can permit prediction. Individuals who take the models developed by scientists and live by predicting result are engineers, and ultimately technicians who apply a body of knowledge developed by scientists. Many scientists do little more than describe an existing phenomenon.

Physics has, of course, reached the point where description of the phenomenon under study can *only* be done through the use of extensive and detailed models developed by earlier scientists. Psychology, Sociology, and Economics (to name a few) have not reached this level, and by the very nature of the subject being studied will probably never reach any real level of prediction which greatly exceeds that found in the general population.

A scientist does require hard facts. With these facts he will describe, analyze, build models, predict, and test. Based on his results, he will go back to analyzing and model building. The so-called "Voodoo Scientist" has his problem in isolating those hard facts. Unlike the Physicist or Chemist, he is not working with a subject in which phenomena can be isolated and independently experimented on. The ethical problems involved in this are tremendous, and the Nazis showed what can happen if those ethics metamorphose involving groups of people, and the variables to be sampled, as well as those of the results, are often defined only in terms of the theory being tested. Hard facts? Ask an Economist what GNP means.

Does the fact that your phenomenon is difficult to get a grasp on, hard to define and isolate, and impossible to experiment with, mean that the individuals who are describing, analyzing, modeling, testing, and reanalyzing in an organized manner are any less scientists than are the theoreticians who are chasing the magnetic monopole? The scientific method is the only decent tool available to the social scientists. Just because they cannot yet provide a class of engineers and technicians who give you satisfactorily predictable results makes them no less scientists. Predictability in science comes from controlled experiments. When the experimenter is a part of the test group, control groups are prohibitively expensive even if ethical, and the results of an experiment immediately contaminate the group being experimented on; it seems to me that whatever predictability is possible in the social sciences will be only slightly ahead of that available in the general culture. Does this mean that questions in these areas should not proceed scientifically?

Mr. Pournelle's discussion of the social sciences appears to me to be no more accurate than John Holt's discus-

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sion on space colonies. I would propose a hypothesis that scientists who write on subjects outside the area of their primary training and expertise are no more accurate than nonscientists. Dr. Schmidt, do you think that you or Mr. Pournelle could help me to set up a valid research process which would confirm or deny my hypothesis?

RICHARD BREWER

College Station, TX

Your hypothesis is a generalization with, at best, statistical validity. I know lots of people, scientists and otherwise, who are highly competent in one or more fields besides "the area of their primary training and expertise"; I know others who are not. Each case needs to be evaluated individually—and it's not a bad idea to bear in mind that mistakes can be made even in *an expert's area of expertise!*

Brass Tacks

A comment on G. Harry Stine's "The Alternate View," November '83 issue, "Garbage In, Confusion Out." The tenet of the Swartzberg Test ("the validity of a science is its ability to predict") would preclude any posibility of a science being influenced by human endeavor.

Because economics is the result of human action, and because human action is frequently unpredictable, economics will never qualify for the label of a science.

ART WARNER

Woodbridge, CT

You seem to be making the fundamental assumption that human behavior is intrinsically *unpredictable, which may or may not be true.*

Dear Stan:

Some of your readers may wish to try these unusual—but low-cost—experiments. They are variations on traditional torsion-balance tests (to determine the value of the Gravitational Constant, G) but they use heated or ultra-cold masses.

A torsion-balance is simply a lightweight rod with a weight at each end, suspended from its center point by a fine wire or nylon line. When the torsion-balance is enclosed in an airtight container case (lined inside and out with metal foil and electrically grounded) it becomes a very sensitive device for measuring gravitation. My most recent torsion-balance is 10 feet long, making it ultra-sensitive, with a three-pound lead weight at each end. (Fishing net sinkers from Sears!) A mirror is fastened to the side of the balance beam and a glass covered window allows a light beam to be reflected off the mirror. I used an ordinary slide projector for the light source; one strand of a fine, spiderweb (or human hair) is taped to a glass slide and used as a reflected reference line that goes back to a graph paper chart mounted on the wall. As the vertical reference line travels across the graph paper, a pencilled dot can be placed on the paper once a minute—with the dots moving up one square of the paper each minute. A motorized chart recorder would save a great deal of labor and time but it is not essential.

Conventional experiments of this kind maintain all the equipment at a uniform temperature, varying less than one degree—in order to measure the per-unit force of gravitational attraction with ever increasing precision. However, this procedure makes it impossible to find out if changes in temperature might affect gravity. After several false starts, I decided to use a high-fire electric kiln (on wheels) as the mass causing the torsion balance to rotate. It is loaded with 70 pounds of common bricks and driven

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to higher temperatures: at a considerable distance from the torsion balance. With the electrical current distance from the torsion balance. With the electric current turned off the heavy, 'driving mass' is then placed along side the container case, in line with one of the small, three-pound masses. Of course, both the kiln and container case are heavily insulated. To my surprise, the gravitational attraction increased with each 100°C increase in temperature! The commercial pyrometer on the kiln is only accurate to within a few percent but it appears that doubling the temperature *doubles the attraction.*

I also used 220 pounds of lead to rotate the torsion balance. When the temperature of the lead was reduced to that of dry ice the attraction decreased by an amount consistent with the above heated-mass experiments. The results of these tests can be applied to astronomical objects. For example, it can be predicted that two planets—exactly the same size and made of similar materials—will have very different gravitational-attraction values if one is hot and the other cold. Luckily, there are two such 'planets,' Mercury and Jupiter's large moon Callisto—at least the Voyager photographs showed that Callisto looks like an identical twin of Mercury. This was a great surprise to the expert planetologists because it had long been known that Mercury is three times as 'attractive' (massive) as Callisto. The hot-and-cold gravity experiments explain this fact in a new way: solar heated Mercury is three times as hot as cold, distant Callisto. Thus the experiments predict that the relatively cold Callisto will have only one-third the gravitational attraction value of Mercury even if they are both made of basically similar materials—as the photographic evidence suggests.

There are dozens of additional consequences that spring from these hot-and-cold gravity tests but the first order of business is to have them repeated by as many experimenters as possible. If you write to me, c/o *Analog*, and enclose a stamped, self-addressed number 10 envelope, I will send drawings and details. The costs are low in relation to the new knowledge about gravitation that can be gained.

SAM ELTON

Manhattan Beach, CA

Dear Dr. Schmidt,

Once again, a Spider Robinson appears in your illustrious magazine. It's hard to say whether the puns thrown out with malicious spide(r) are the worst or the best part of the story, and of course there is always the story line itself, and the characters, and the . . . Well, it's tough to pick out one aspect for praise over any other, just as it is tough (impossible?) to find Callahan's if you don't need it.

And yet, one of the good things, a minor point to display the mastery of this Spider fellow in his craft, is that I don't think that I've ever run into a formula description of the quirks and customs of the Place. Each time, the whole story is told exactly as if it is a tale told in front of a fire, or told with a couple of beers. In short, this is a story teller we have here, not an ordinary author.

So, laud praises, Dr. Schmidt, and here's to you, Mr. Robinson, we-jus love you more than you can know. A round of God's Blessing for us all!

ROBERT RETHERFORD

Hanover, IN ■

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a calendar of analog upcoming events

25–27 May
V-CON 12 (B.C. SF conference) at University of British Columbia Conference Centre, Vancoucer, B.C. Guest of Honour—Samuel R. Delany, Special Guest—Elizabeth A. Lynn, Fan Guest of Honour—Debbie Notkin. Registration—C$25. Info: V-Con 12, Box 48478, Bentall Centre, Vancouver B.C. V7X 1A2 Canada.

4–7 June
11th Annual Symposium on Computer Architecture at Ann Arbor, Mich. Info: Keki B. Irani, Dept. of ECE, University of Michigan, Ann Arbor MI 48109. 313–764–8517.

13–15 June
NECC 84 (National Educational Computing Conference) at Dayton, Ohio. Info: Lawrence A. Jehn, CS Department, University of Dayton, Dayton OH 45469. 513–229–3831.

21–24 June
DEEPSOUTHCON 22 (Annual Southern SF conference) at Read House, Chattanooga, Tenn. Guest of Honor—Joan D. Vinge, Artist Guests of Honor—Doug Chaffee and Bob Maurus, Fan Guest of Honor—Jerry Page, TM-Karl Edward Wagner, Special Guests—Somtow Sucharitkul, Timothy R. Sullivan. Registration—$15 until 1 June, $20 thereafter. Banquet (limited to 150)—$10. Info: DeepSouthCon 22, c/o Irv Koch, 835 Chattanooga Bank Building, Chattanooga TN 37402. 404–767–7360.

22–24 June
National SF Research Association meeting (academic) at University of Missouri—Rolla. Info: Wayne Cogell, G–7 Humanities/Social Sciences, University of Missouri—Rolla, Rolla MO 65401. 314–341–4131.

29 June—3 July
INCONJUNCTION 4 (Indiana SF conference) at Airport Hilton Inn, Indianapolis, Ind. Guest of Honor—Joe Haldeman, Fan Guests of Honor—Roger Sims and Fred Prophet, TM—Bob Tucker. Registration—$12 until 15 June, $15 at the door. Info: Inconjunction 4, Box 24403, Indianapolis IN 46224.

29 June–3 July
WESTERCON 37 (Westcoast SF conference) at Marriott Hotel, Portland, Ore. Guest of Honor—Harlan Ellison, Artist Guest of Honor—Alex Schomburg, Fan Guests of Honor—F.M. & Elinor Busby, TM—Ed Bryant. Registration—$30 to 15 June, $40 at the door ($9 supporting at all times). Info: Westercon 37, Box 16155, Portland OR 97216. 503–761–8768.

30 August–3 September 1984
LA CON II (42nd World Science Fiction Convention) at Anaheim Convention Center, Los Angeles, Calif. Guest of Honor—Gordon R. Dickson, Fan Guest of Honor—Dick Eney, TMs—Robert Bloch & Jerry Pournelle. Registration—$40 until 31 December 1983, more later and at the door. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition, the works. Join now and get to nominate and vote for the Hugo awards and the John W. Campbell Award for Best New Writer. Info: LA Con II, Box 8442, Van Nuys CA 91409.

—Anthony Lewis

Items for the calendar should be sent to the Editorial Offices six months in advance of the event.

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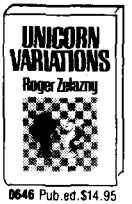

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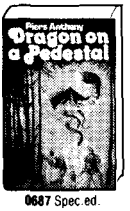
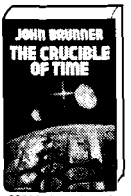


0687 Spec.ed.



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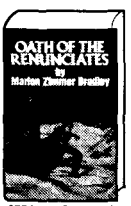
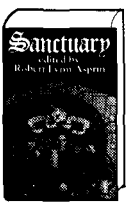
0653 Pub.ed.$15.95

0620 Pub.ed.$11.50

0695 Hiero's Journey; The Unforsaken Hiero. Spec.ed.



0554 The Shattered Chain; Thendara House. Spec.ed.



0539 Thieves' World; Tales from the Vulgar Unicorn; Shadows of Sanctuary. Spec.ed.

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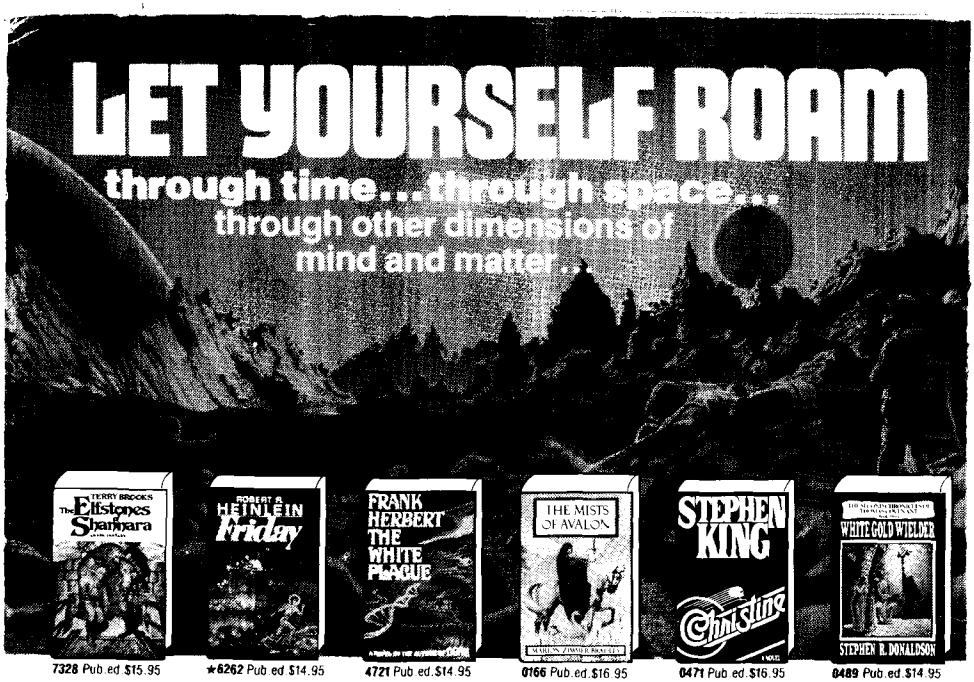

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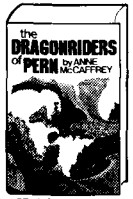

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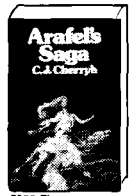

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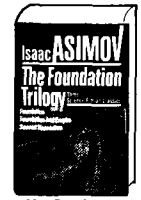

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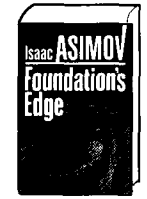

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